Lessons Learned in Leveraging Historical Cost, Schedule and Technical Data

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Abstract Review

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The process of applying historical cost, schedule and technical data to develop new program estimates is often more difficult than textbooks suggest.

Definitely! After two large projects (and many smaller ones), we saw a pattern…

The paper provides real-world insight to the issues that arise when capturing, analyzing and applying data for the next estimate.

Starting with the GAO 12-step process made sense…

The goal is to integrate information from multiple products, systems and subsystems to develop defendable estimates.

In reality, an incremental structured approach was most productive – but flexibility in sequence and approach appears to be a key

Lessons learned include experience and best practices when working with financial, engineering, manufacturing and program management SMEs.

Today we'll share our steps & lessons… but let's hear from you too!

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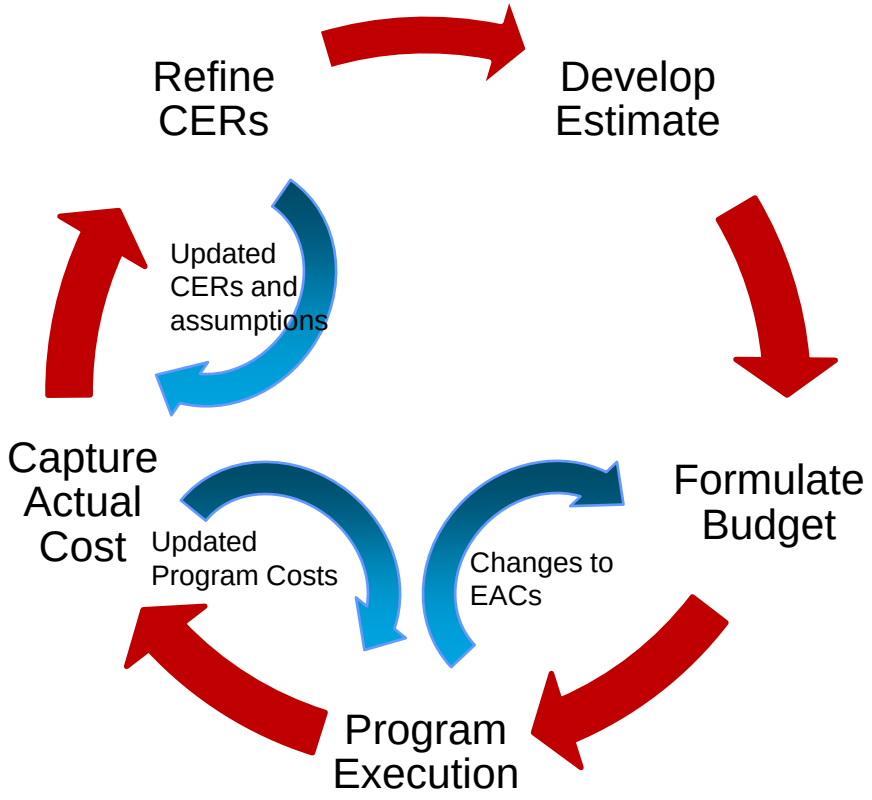
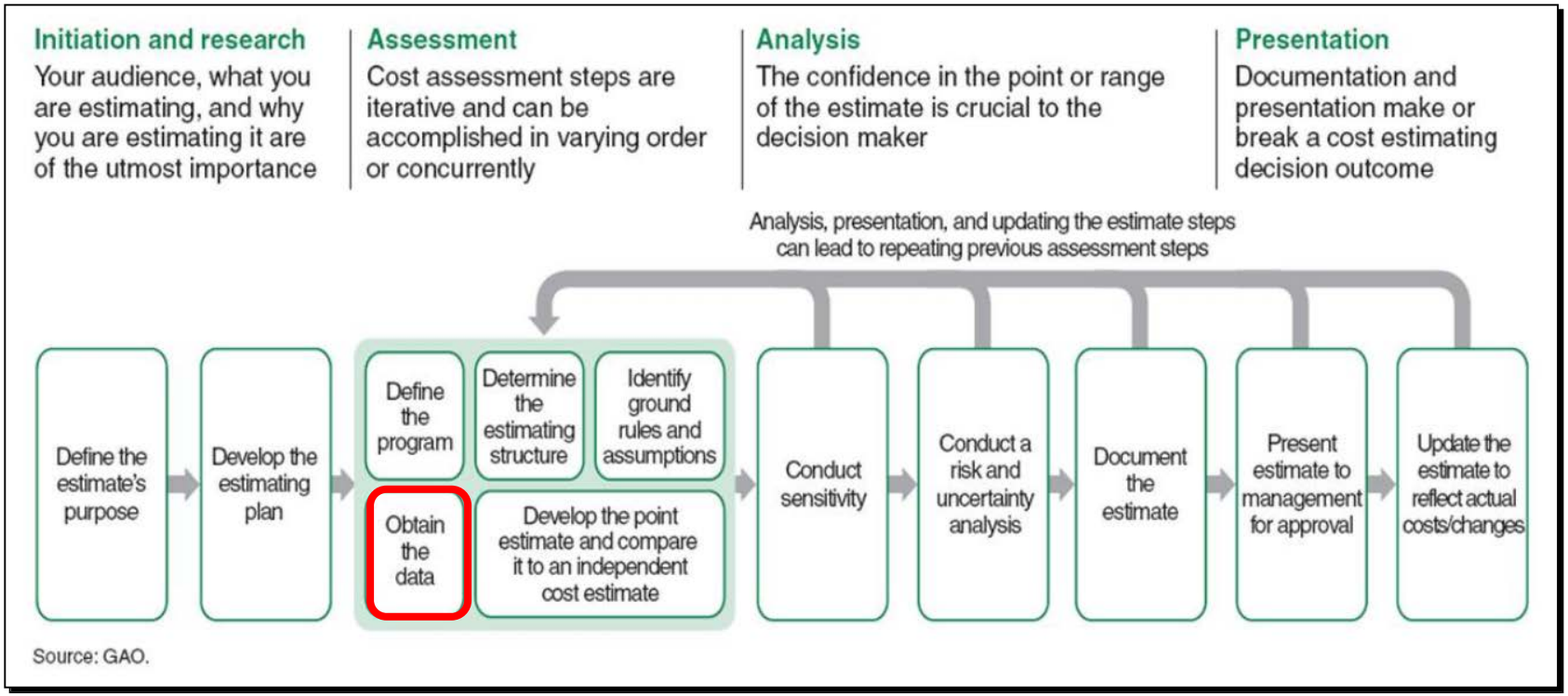
Cost Estimating is a Cyclical Process with past programs informing future estimates…



…However there are exceptions

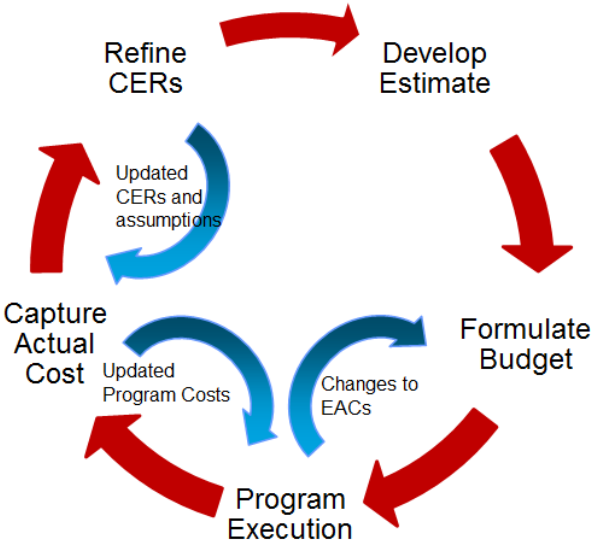
Introduction to GAO 12-Step Process

- GAO (General Accounting Office) created the 12-Step process in 1972; still valid today
- Provides repeatable process for developing cost estimates
- This paper focuses on Step 6: "Obtain the Data" i.e., Data Mining



Typical Tasks: Data Mining

- Decide on parameters for study
- Develop an initial methodology
- Outline study ground-rules
- Identify stakeholders
- Schedule interviews of stakeholders
- Characterize past project parameters
- Normalize past project actuals
- Identify subsystems with suitable data
- Calibrate suitable subsystems parameters
- Decide on next-steps for further study



Creating Data Collection Plan

- Document the plan…write it down!
- Data collection is lengthy process; continues throughout estimate
- Four main types of data:
  - Cost
  - Schedule
  - Program
  - Technical
- What types of data do you need?
- What types of data are available?
- Develop plan to bridge the gap between these two questions

Data Collection Sources

- Some sources require advance notice for access / clearance
- Sources include:
  - Program Management Plan
  - Cost Analysis Requirements Document (CARD)
  - Integrated Master Schedule
  - Specifications
  - Drawings
  - Size, Weight & Power (SWAP)
  - Labor Rates and Inflation Tables
  - Earned Value data
  - Publicly available sources
  - Paid access sources (i.e. ISBGS®)

Interviewing Sources

- Ensure both the interviewer and interviewee are prepared!
- Interviewing is part of the “art” of cost estimating
- Avoid “yes or no” questions or seeking point estimate values
- Bad example:
  - Question: Are we buying 100 widgets this year?
  - Answer: Yes!
- Better example:
  - Question: How many widgets are we buying this year?
  - Answer: We want to buy 100, but we may buy between 80 and 120, based on price.
- Second example provides idea of uncertainty around quantity
- As always, documentation is critical

Data Collection Form – example

		Programmatic and System Level Da
System level aircraft		
2	Number of Flying protos	
	Number of Static Test Articles	1
	Number of Ground Test Vehicles	1
1	Number of "other" full scale vehicles	TSTB
Program Schedule (dates) (as known)		
Jan-10	Milestone A (VSM) - competres to production program	
Jul-10	Contract Start Date	
	Milestone B	
Jul-11	PDR "complete with basic data"	
Dec-12	CDR	
	Milestone C/LRIP	
	FRP	
Jan-15	Fiirst article complete (ground runs start)	
	IOC	
	FOC	
May-15	First Flight	
Sep-16	end of fight test	
TBD	conceptual design review (CODR date)	
System Test		
38	System (Flight prep) Ground Test hrs	
200	TSTB Hrs	
TBD	SIL Hours	
Flight Test hrs		
66	Fully Instrumented	Safety
	Partially Instrumented	
	Avionics	
	Function & Reliability	
	Auto. Flight Control	
	Gov't Acceptance Test	
	Other	

	Total Test Equipment $					
	# SILs					
1	Avionics		With Flight Controls - includes simulator time & software development			
	Flight Controls					
	Certification Level (select one)					
	Commercial					
	Military manned					
	Military unmanned					
X	Demonstration/Proto					
System Engineering/Program Management						
50	Number of SE CDRLs		add 50 for avionincs			
gazillion	Number of trips/travel					
500	Number of requirements		system level			
5	Number of KPPs		4k 95, speed, empty weight fraction ----			
25	Number of TPMs					
90%	% Attribute Groups Cost of total SE Cost					
ILS						
5	# of PSEs (Peculiar Support Equipment) items		no ILS engineers			
5	# of CSEs (Common Support Equipment) items					
	Data					
	Publications (number of pages for tech pubs)		None - "free form" engineering instructions - Russ Halstead (test lead)			
	Engineering Data (how measured?)		deliverable documentation (CDRLs) -			
	Data management (how measured?)		5%			
	Data Storage (how measured?)		negligable			
	Training					
	Training (number of training pages)		20 pagers			
	Trainers (number of training devices)		SIL - redundant with above			
	Services		engineering did this			
	Number of O, I and D level sites (to determine intial spares and support equip)					
	Organization level sites		All in west palm			
	Intermediate level sites					
	Depot level sites		Part supplier			
System Engineering Inputs						
Development Info					PRICE-H factors	TruePlanning factors
					ECMPLX	System Complexity
1	System Complexity	☐	No Changes - existing design/off the shelf		1	50
		☐	Simple modification to existing design			
		☐	Typical, Familiar - Extensive modification to existing design			
		☐	Moderate - New design using established technology			
		☑	Complex or Unfamiliar - New design, New Product Line			
		☐	Complex and Unfamiliar - New design different from established product line and requiring development of new components, materials, or processes			
2	Experience of SE Team	☑	Very High - Extensive experience with similar designs		(incorporated in ECMPLX - above)	
		☐	High - Normal experience with similar designs (default value)			
		☐	Mixed experience, some familiar some new			
		☐	Low - Unfamiliar with design, many new to the job.			
					INTEGS	xternal Integration Complexity for Structure
3	System Level Structural/mechanical Integration	☐	Simple Interface, no machining, simple bolt down		1	5
		☐	Routine, alignment, standard tools, no machining			
		☐	Medium Precision alignment, moderate machining/shimming			
		☐	Medium Precision alignment, special tools, dim measure			
		☑	Difficult interface, precision alignment, full spec test			
	Colocated?		Yes			
	Team turnover		very low (1%)			
	IPT		Yes			
	Standard Process?		Adapted and documented			

Collecting and Normalizing Data

- Collection is just one step in a series to develop an historical data set
- Data points are often (usually) are not in the format we need
  - Level of detail may be incorrect
  - May require escalation or de-escalation
  - Cost or price
- Normalization aligns data points in same format for comparison
  - Cost units: may require inflation or currency adjustments
  - Size units: metric units or imperial units?
  - Groupings: mission types, commodities, recurring vs. nonrecurring costs
  - Technology maturity: solid state electronics or vacuum tubes?
- Other Issues: EV, WBS-mapping, completeness, reassignment
- Document any ground rules or assumptions used for normalization
  - Exchange rates
  - Inflation indices
  - Technology or grouping definitions

Biggest Lessons-Learned

- **Obtain management support** prior to data collection effort with a clear plan and expected results
- **Schedule SMEs** (PMs/Engineers & CAMs) with flexible timing and patience
- **Prepare** "Parametric" and other cost, technical and programmatic data templates to provide consistent method for interviews and to limit rework and re-requests
- **Appreciate** that time with SMEs **is limited, send templates** to SMEs for review **ahead of time**, and **know** that they also want the best outcomes
- **Accept** that memory, fidelity and availability may vary by SME and subsystem
- **Provide SMEs with feedback** once initial results ready – they will appreciate that their knowledge and work helped the process
- **Document, Document, Document** – be sure to have complete history of the data collection and normalization
- **Expect** that process will take time and that it's not free for either the data collector or provider!
- **Update or validate** data set periodically to maintain credibility
- **Expect management** (and customers) to appreciate the results of a well documented and efficient data collection process and event

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