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WOULD A COST GROWTH FACTOR HELP ALLEVIATE CONTINUING COST OVERRUNS? (THE IMPROBABLE DREAM)

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AGENDA

- Objective
- Background
- Causal Influences
- Proposed Solution
- Implementation
- Way Ahead
- Discussion
- References

OBJECTIVE

- Develop a procedure to minimize budget overruns by strengthening the fidelity of cost estimates in quantifying the impact of unforeseen events

▶ (**Disclaimer:** The opinions expressed herein are strictly those of the author)

BACKGROUND

- Programs continue to overrun budgets despite our best efforts to produce complete and accurate cost estimates
- This occurs even though we use the most current and accurate technical & programmatic parameters available
 - Weights
 - Bills of materials
 - Hardware descriptions
 - Power requirements
 - Software information
 - Quantities
 - Schedule
 - Etc.

BACKGROUND (CONT.)

➤ Cost models

- Incorporate the most current cost history
- Utilize statistics in calculations
- Quantify historical and known uncertainties or risks
 - Often referred to as **'Known Unknowns'**

BACKGROUND (CONT.)

- Volatility, variability, and distributions are accounted for in:
 - Rates and skill levels
 - Cost Estimating Relationships (CERs)
 - Factors
 - Rework and redesign
 - Attrition
 - Planned in-scope and possible technical, schedule, and configuration changes
 - Phasing & schedules
 - Software Lines of Code and growth
 - Weights
 - Legacy and dependency impacts
 - Productivity, efficiency and realization
 - Improvement curves
 - And so on

BACKGROUND (CONT.)

- There is the attempt to estimate and budget at high confidence levels
- Yet there are still overruns

WHY???

CAUSAL INFLUENCES

- There are unknowns that we cannot or do not quantify
- We account for
 - Predictable or previously experienced events
 - Variability captured in the range of historical trends and technical data used
 - Information that is statistically derived and apply it accordingly
- Much of the history and techniques we use exclude certain events
 - Unpredictable or unforeseen incidents
 - Experiences, occurrences and variability outside the range of historical trends and data
- Sometimes such occurrences are labeled as 'Unknown Unknowns'
 - They could be considered as 'Knowns' as we know that the unknown will occur!

CAUSAL INFLUENCES (CONT.)

➤ CERs

- Reflect the past and not the future
- Are often log normal and have definite end points unlike what would be predicted by the actual data set
- Are sometimes ‘tailored’ so that not all exceptionally unusual events and outliers are included
 - This is also the case with other cost models, trends, and databases

➤ The history used is limited

- From programs that were completed
- Excludes projects that were terminated and that had severe problems
- These events could be experienced again

➤ There are unplanned or out of scope changes to the task

- These changes aren’t anticipated and occur as both the state of the art and user needs evolve
- Requirements creep and engineering change proposals result

CAUSAL INFLUENCES (CONT.)

- Program Manager, Technical Team, and Integrated Product Team (IPT) optimism often leads to an underestimation of requirements and project realities
 - Only the 'A' team will be involved
 - The program won't repeat the mistakes made previously
 - It will invent new ones
 - The job is more mature than it is
 - It's commercial or uses Commercial Off The Shelf (COTS) hardware or software
 - Which should therefore be free in some mindsets
 - Overstating of heritage and legacy
 - Understatement of dependencies or correlation
 - Unrealistic schedules are envisioned
 - Etc.

CAUSAL INFLUENCES (CONT.)

- Government Accountability Office (GAO) Report [Reference 1]
 - “For the most part, **cost growth has not been caused by poor cost estimating**... Our analyses of six ongoing space programs found that original **cost estimates were particularly unrealistic about** the promise of savings from **increased contractor program management responsibilities**, the constancy and availability of **the industrial base**, savings that could be accrued from **heritage systems**, the amount of **weight growth** that would occur during a program, the availability of mature technology, the stability of funding, the **stability of requirements**, and the achievability of **planned schedules**. **At times, estimates that were more realistic in these areas were available** to the Air Force, **but they were not used**”.
- GAO testimony [Reference 2]
 - “In our 2005 department-wide assessment of selected major weapon programs, we found that **only 15 percent of the programs we assessed began development having demonstrated all of their technologies mature**”.

CAUSAL INFLUENCES (CONT.)

- Another influence leading to optimism is the need to win or continue the job by contractors and program managers
- There is pressure to stay within an already established often arbitrary budget
- Defense Acquisition University (DAU) [Reference 3]
 - “**Budgets may be** deliberately overstated...to minimize need for variance reporting, or **deliberately understated** by a manager’s supervisor to reduce possible over consumption of resources.”
- “The Elusive Challenge of Estimating Costs” [Reference 4]
 - “The GAO has found repeatedly ... that **programs produce optimistic estimates in order to gain approval for funding.**”

CAUSAL INFLUENCES (CONT.)

- Other factors leading to cost growth that aren't included in most estimates
 - Political actions
 - 'Acts of God' (hurricanes, floods, tornados, earthquakes, etc.)
 - Strikes and labor disruptions
 - Replacement of contractors or vendors
 - Expenditure profile fluctuations

Certainly this list is not complete

CAUSAL INFLUENCES (CONT.)

- Most of these events can't be statistically derived or defined
- Historical actuals, estimates, and budgets may not have visibility into the resultant costs
- The exact amount of experienced and needed additional money cannot be exactly calculated

CAUSAL INFLUENCES (CONT.)

- Often these items are represented as being budgeted in as Management Reserves
 - The DoD 5000.4M-1 Contractor Cost Data Reporting (CCDR) Manual [Reference 5] defines Management Reserves as “The **amount of the total allocated budget** that is held back **for management control and risk purposes at the total contract level rather than designated for the accomplishment of specific tasks**”.
 - According to the GAO [Reference 6], “**Management Reserves are** a part of the total project budget intended **to be used to fund work** anticipated but **not currently defined.**”
- Management Reserves are often viewed as ‘low hanging fruit’ to be ‘harvested’ in order to place funding elsewhere

The terminology “Management Reserves” can mean different things to different parties

CAUSAL INFLUENCES (CONT.)

- This discussion will not refer to the need for funding such events as Management Reserves
- We could refer to these simply as '**Cost Growth**' items
 - Must be approached as something other than Management Reserves
 - Explained differently
 - Sold to decision makers as being essential for a successful program
- The quantification of such events will entail a more detailed approach than using a single given value
 - Management Reserves are usually established and applied as a given percentage

PROPOSED SOLUTION

- Develop, calculate, and apply a multiplier needed to capture such events
- This will be referred to as the **“Cost Growth Factor”**
- It is dependent on and determined by
 - **‘Maturity’ or Technology Readiness Level (TRL)**
 - **‘Additional Factors’**

PROPOSED SOLUTION (CONT.)

- The **Maturity** or **Technology Readiness Level (TRL)** may be assessed in the following increments:

TRL Levels	
1	Basic principle observed
2	Conceptual design formulated
3	Conceptual design tested
4	Critical function demonstrated
5	Component/Breadboard model tested in relevant environment
6	Prototype/Engineering model tested in relevant environment
7	Engineering model tested in space or operating environment
8	Flight-qualified system
9	Flight proven system
(Level 7 and on is considered 'mature')	

PROPOSED SOLUTION (CONT.)

- As well as “Maturity”, the multiplier needs to consider “Additional (mostly qualitative) Factors”
- According to the DAU [Reference 3] the “... budget is sensitive to
 - Contract category...
 - Differences in the weapon systems purchased by each service...
 - The contractors that build the systems.”
- There are other considerations!

PROPOSED SOLUTION (CONT.)

➤ The “Additional Factors” include:

- Complexity
- Quantity
- Program Stage
- Procurement Type
- Contract Type
- Operating Environment
- Program History
- (These may tend to be subjective and are not mutually exclusive)

PROPOSED SOLUTION (CONT.)

➤ Additional Factors descriptions:

- **Complexity**

- Difficulty of the job as it relates (technically and mechanically) to systems, hardware, software, and integration
- Complexity can be attributed to the number of
 - Interfaces
 - Subsystems
 - Assemblies and subassemblies
 - Segments
 - Computer Software Component Interfaces (CSCIs)
 - Contractors and subcontractors
 - (And associated variables)

- **Quantity**

- As more units are manufactured there is a greater potential to recover from disruptions and to implement effective processes
- Quantity relates to
 - The number of units
 - And/or standard hour content

- **Program Stage**

- Development has more aberrations than follow-on production or operations and support tasks

PROPOSED SOLUTION (CONT.)

➤ Additional Factors descriptions (cont.)

- **Procurement Type**

- With an extended supply chain there is less influence and control over subcontractors
- Many contractors are harder to manage
- Contractor experience level is also an influence

- **Contract Type**

- There is less incentive with a cost plus contract with less risk for the contractor

- **Operating Environment**

- A military or space system must withstand more rigorous constraints than a commercial ground based system

- **Program History**

- Having actual history (or history from a very similar established program) to draw on will result in estimates with greater inherent fidelity

PROPOSED SOLUTION (CONT.)

- A table can be constructed to quantify the influence of these elements:

Additional Factors			
Factors	Benign	Adverse	Points
	(Each = 0 points)	(Each = +1 point)	
Complexity	Low	High	
Quantity	High	Low	
Program Stage	Production, O&S	All (including Development)	
Procurement Type	Make	Buy	
Contract Type	Firm Fixed Price	Cost Plus	
Environment	Commercial	Military	
Program History	Established	New	
Total			

Score For Additional Factors	
Points	Rank
6 or more	A
5	B
4	C
3	D
2	E
1	F
0	G

PROPOSED SOLUTION (CONT.)

- A program could then be ranked (for example) as:

Additional Factors			
Factors	Benign	Adverse	Points
	(Each = 0 points)	(Each = +1 point)	
Complexity	Low	High	0
Quantity	High	Low	1
Program Stage	Production, O&S	All (including Development)	1
Procurement Type	Make	Buy	0
Contract Type	Firm Fixed Price	Cost Plus	1
Environment	Commercial	Military	1
Program History	Established	New	1
Total			5

- This would be 5 points or a 'B' ranking

PROPOSED SOLUTION (CONT.)

- Certainly there are other factors
- Some of these that could be considered (and are equally hard to quantify) are
 - IPT and/or Government team involvement and experience
 - Political pressures
 - Volatility (program or project stability)
 - Type of product
- All of these “Additional Factors” should
 - Have definitions developed
 - Be expanded on
 - Should be adjusted for the specific area of focus

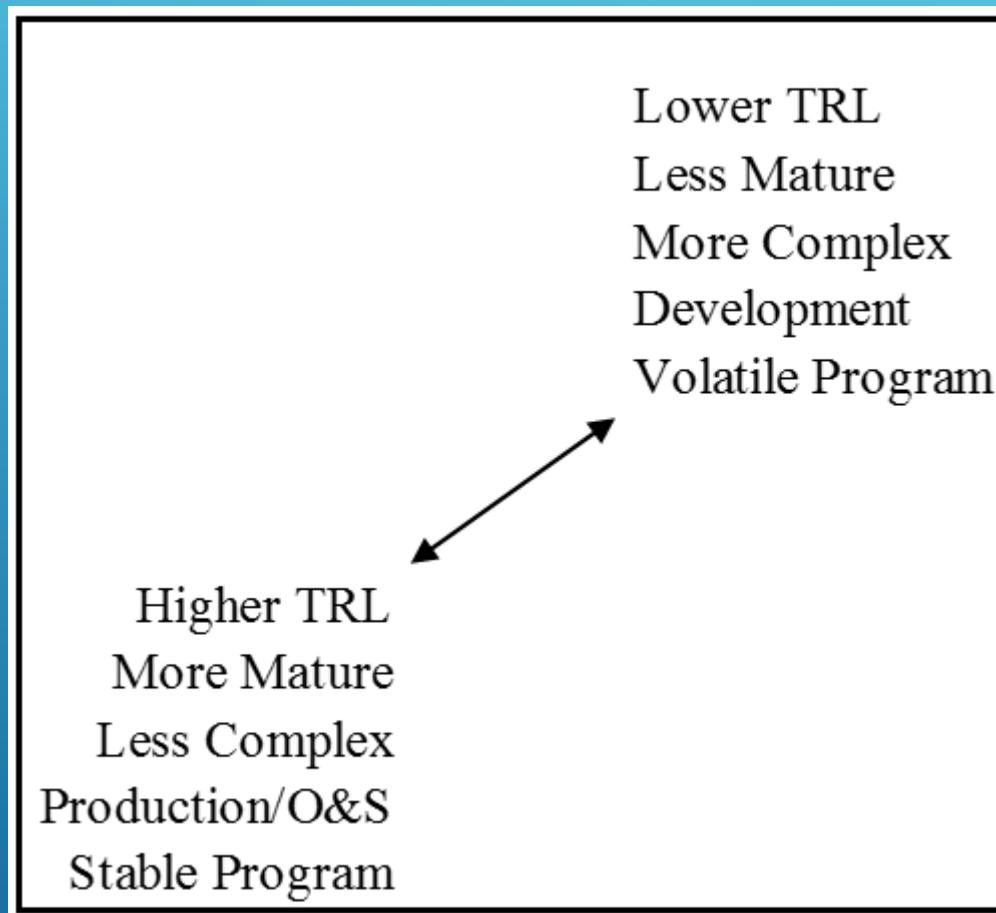
PROPOSED SOLUTION (CONT.)

- A matrix based on the 'Maturity' and 'Additional Factors' can then be constructed to derive a "Cost Growth" multiplier
- Example:

Cost Growth To Apply								
		TRL						
		7 or Greater	6	5	4	3	2	1
Additional Factors Rank: Complexity; Quantity; Program Stage; Procurement Type; Contract Type; Environment; Program History	A	1.150	1.175	1.200	1.225	1.250	1.275	1.300
	B	1.130	1.154	1.178	1.203	1.227	1.251	1.275
	C	1.110	1.133	1.157	1.180	1.203	1.227	1.250
	D	1.090	1.113	1.135	1.158	1.180	1.203	1.225
	E	1.070	1.092	1.113	1.135	1.157	1.178	1.200
	F	1.050	1.071	1.092	1.113	1.133	1.154	1.175
	G	1.030	1.050	1.070	1.090	1.110	1.130	1.150

PROPOSED SOLUTION (CONT.)

➤ Resultant matrix indicators:



PROPOSED SOLUTION (CONT.)

- The factors in the example matrix are
 - Notional Rough Order of Magnitude (ROM) values
 - The Range is 3% - 30% Determined by
 - Delphi method
 - Polls on space systems performance
- The Range is 3% to 30%
 - Represents nominal step increases leading up to an order of magnitude from the minimum
 - The midpoint or average increase is ~15%
 - Correlates with Air Force Space and Missile Center (SMC) financial management information
- For more precision
 - These need to be expanded on through experience and definitions created
 - They need to be calibrated and validated for different applications

PROPOSED SOLUTION (CONT.)

- There is always a likelihood of some factor totally beyond government, human, or contractor control influencing cost
- Therefore, some growth must be predicted for every program
- A single unforeseen event can significantly impact a program

IMPLEMENTATION

- The multiplication factor derived from this table should be applied to total contractor and government costs for purposes of simplicity
- Then it may be allocated downward to the WBS or any other level that may be desired so as to demote visibility
- Since it isn't known where specifically the additional funding will be needed it may require redistribution as the program or project evolves

IMPLEMENTATION (CONT.)

- This “Cost Growth Factor” is
 - Additional to other risks and uncertainties
 - Should impact all confidence levels

- It may be imprecise in its quantification and the attributes defining it are not exact

- Should be applied as a range in a Monte Carlo or similar modeling simulation in the following manner

IMPLEMENTATION (CONT.)

- Example (Assuming a TRL of 4 and Additional Factors Rank of D):

		Cost Growth To Apply						
		TRL						
		7 or Greater	6	5	4	3	2	1
Additional Factors Rank: Complexity; Quantity; Program Stage; Procurement Type; Contract Type; Environment; Program History	A	1.150	1.175	1.200	1.225	1.250	1.275	1.300
	B	1.130	1.154	1.178	1.203	1.227	1.251	1.275
	C	1.110	1.133	1.157	1.180	1.203	1.227	1.250
	D	1.090	1.113	1.135	1.158	1.180	1.203	1.225
	E	1.070	1.092	1.113	1.135	1.157	1.178	1.200
	F	1.050	1.071	1.092	1.113	1.133	1.154	1.175
	G	1.030	1.050	1.070	1.090	1.110	1.130	1.150

In this case, the resultant factors (triangular distribution) would be

- Best Case = 1.113 ~ 10% Confidence Level
- Most Likely = 1.158 ~ 50% Confidence Level
- Worst Case = 1.203 ~ 90% Confidence Level

WAY AHEAD

- This is a procedure that is in the formative stage, but is suggested for consideration and application
- The desired way ahead is
 - Initially implement this approach based on the notional increases outlined
 - Then refine the procedure and data used
- Currently it's to some extent subjective and based on 'heuristic' data
 - A database needs to be constructed
 - The model needs to be validated and calibrated for a range of situations
 - Different programs and companies will require varying amounts of cost growth due to their distinct maturity, complexity, volatility, and the like
 - The definitions of the parameters necessitate codification

The "Cost Growth" factor will aid in minimizing overruns and will become increasingly accurate as it becomes refined

WAY AHEAD (CONT.)

- We will need to “sell” this approach to shareholders by
 - Explaining underlying logic
 - Demonstrating the benefits of its use
- We must be on guard to prevent this technique from being ‘gamed’ by the overly optimistic
- By implementing this method now the result will be
 - Increased accuracy in projections
 - Ability to execute programs successfully within the established budget
- As we employ this tool it will
 - Evolve
 - Aid us in creating viable forecasts with additional fidelity



DISCUSSION

- Questions?
- Comments?
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