Analyzing the Contingency Reserve for DHS Cybersecurity Acquisitions Programs

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Abstract *— This paper presents a research study made on multiple Department of Homeland Security (DHS) Cyber-security major acquisition programs cost estimates' uncertainty and risk analysis results and the determination of a Contingency Reserve in a program's cost estimates. This study will analyze the use, application and behavior of the Contingency Reserve within such programs. The value of this research will be to provide program managers and decision-makers an assessment of the amount of Contingency Reserve needed to protect a Cyber-security program from cost overruns due to risk and uncertainties in its estimates.*

Keywords*— Contingency, Cost, Estimate, Risk, Reserve*

INTRODUCTION

Because U.S.A citizen's daily life, economic vitality, and national security depend on a stable, safe, and resilient cyberspace, the federal government has engaged on huge efforts to builds the national capacity to defend against cyber-attacks.

The effort made by the Federal Government to secure its Cyberspace comes at a cost. This study will analyze historical data from multiple cost estimates created in support of different cyber-security programs. In order, to make better future assumptions and to help mitigate the inherent cost estimating risk and uncertainties that come from estimating, the focus of this paper will be centered around the use and application of the Contingency Reserve.

PROBLEM STATEMENT

It is an established rule that programs must use a 50% confidence interval as the basis for the objective cost with the Threshold being set up to 15% above the objective cost parameter. Subsequently, program offices always fund programs at the 50% confidence level regardless of the program's risk, uncertainties and/or their complexity. Having adequate funding is paramount for optimal program execution since it can take many months to obtain the necessary funding to address an emergent program issue.

Without available risk funding, cost growth is likely, hence the importance of having the actual impact of the risks accounted for. This can be achieved via the correct allocation of a Contingency Reserve.

LITERATURE REVIEW

The term "Reserve" implies something that is set aside, while "Contingency" could be defined as a future event or circumstance that cannot be predicted with certainty. Thus, when the term Contingency Reserve is used, it usually speaks about the money set aside for unexpected events so that the project will still have enough funding to carry on and to actively and strategically manage project risks.

Shrivastava explains that contingency reserve is time and/or money allocated to address identified risks, that is a critical part of project risk management [1]. The Project Management Institute defines it as "Time or money allocated in the schedule or cost baseline for known risks with active response strategies" [2]. The above are private sector definitions/descriptions. On the Federal Government side, experts describe the contingency reserve as funding that is added to an estimate to allow for items, conditions, or events for which the state,

occurrence, or effect is uncertain and experience shows are likely to result in additional costs [3].

Why is it used? Simply put, it is used for a project's risk management—this is a way to increase understanding and apply the concept of integrating schedule and cost risks into an approach in using earned value [4]. The Contingency Reserve will be used to address the project risks as they occur, also used to predict project outcomes. The Contingency Reserve pools possible risk so that any occurrence can be absorbed, by doing this, delays and cost overruns will be avoided. Communicating the contingency reserve is a way to show that the project can proceed despite risks that might occur [1].

While the Contingency Reserve is used on the identified or known risks, whereas the Management Reserve is defined as the cost or schedule reserve that is used to manage the unidentified risks. "An amount of the project budget or project schedule held outside of the performance measurement baseline for management control purposes, that is reserved for unforeseen work that is within the scope of the project" [2]. The budget Contingency Reserve of a large-scale project should be calculated with care. If the value is too low, it could lead to losses, even causing the company to go bankrupt [5]. It is important to know that "The contingency reserve is used to manage identified risks, while the management reserve is used for unidentified risks" [6].

There are multiple techniques one could use to calculate the Contingency Reserve. It will depend on each project's unique characteristics and needs. Some of them are: Interviewing, Percentage of the Project's Cost, Decision Tree Analysis, Expected Monetary value, Sensitivity analysis, and Monte Carlo Simulation. Experts agree that the best way to calculate the Contingency Reserve is through quantitative and uncertainty analysis. By calculating it this way, a desired level of confidence to meet the project/program objectives can be determined. Combining the use of Sensitivity Analysis and the Monte Carlo Simulation, a cumulative probability distribution or S-curve can be created. This will help determine the probability of achieving the target objectives when using this method; the Contingency Reserve will be calculated using the difference in cost between the Program Estimate and the desired level of confidence.

It is unrealistic to expect that no risks will occur on a project; that is why project managers, stakeholders, and sponsors need an accurate indicator that the project will not get out of control. The Monte Carlo Simulation enables estimators to create an S-curve that will produce the most realistic probability distribution, using this information management can better quantify the level of confidence they need to complete a project.

RESEARCH BACKGROUND

The Department of Homeland Security (DHS) uses a four-phase framework for managing systems and programs to ensure that the proper time and effort is dedicated to each critical step of the process. There are Acquisition Decision Events (ADEs) that occur at the beginning of and, in some cases, during a phase to make sure the program is progressing well, risks are being tracked and controlled, and the overall program is being managed well before the program moves from one phase to the next.

A Life-Cycle Cost Estimate (LCCE) provides an exhaustive and structured accounting of all resources and associated cost elements required to develop, produce, deploy, and sustain a federal program. Preliminary an LCCE may be developed for each alternative considered during the Analysis of Alternatives (AoA) and a comprehensive LCCE will be developed for the recommended alternative. The LCCE will be reviewed and updated as required at each ADE after ADE-2A. Also, an LCCE will be reviewed and updated after a system is fielded and deployed.

Affordability is the degree to which an acquisition program's funding requirements fit within the agency's overall portfolio plan. Whether a program is affordable depends on the quality and assumptions made on its cost estimate.

Cost estimators utilize various methods to develop a Point estimate. The Point Estimate

provides an estimated cost for all elements and all years within the LCCE. As the program matures through its life cycle and more data become available, or as changes occur, the cost estimator should update the point estimate. Therefore, once the point estimate has been developed, it is important to determine how sensitive the total cost estimate is to changes in the cost drivers.

As a best practice, sensitivity analysis should be included in all cost estimates because it examines the effects of changing assumptions and ground rules. Since uncertainty cannot be avoided, it is necessary to identify the cost elements that represent the most risk and, if possible, cost estimators should quantify the risk. This can be done through both a sensitivity analysis and Risk/uncertainty analysis.

Risk and uncertainty refer to the fact that, because a cost estimate is a forecast, there is always a chance that the actual cost will differ from the estimate, as observed in ~~figure~~ Figure 1. Moreover, a lack of knowledge about the future is only one possible reason for the difference.

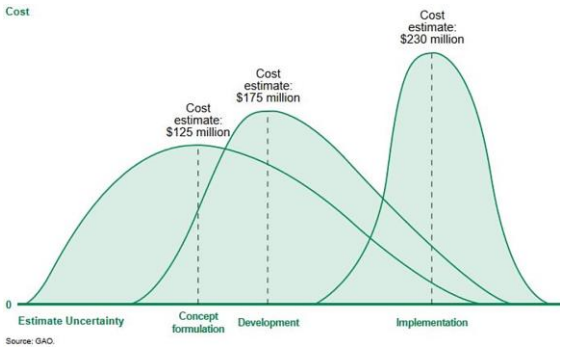

Figure 1
Cost Estimates Across Acquisition Life Cycle

A way to determine whether a program is realistically budgeted is to perform uncertainty analysis so that the probability associated with achieving its point estimate can be determined. A cumulative probability distribution, more commonly known as an S-curve usually derived from a simulation such as Monte Carlo, can be particularly useful in portraying the uncertainty implications of various cost estimates. Figure 2 shows an example of a cumulative probability distribution with various cost estimates mapped to a certain probability level.

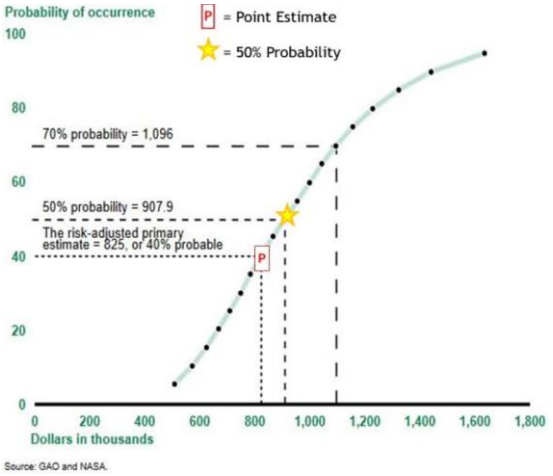

Figure 2
A Cumulative Probability Distribution, or S-curve

ANALYSIS APPROACH

The idea behind this research was to collect and analyze the Contingency Reserve data from past cost estimates for the DHS Cybersecurity portfolio of programs. Data was available but not centralized and basic statistics were unknown and had not yet been studied in aggregate.

The data collected came in the form of ACEIT cost estimating software risk-adjusted models. Thirty-four cost estimates, from three different components and six separate programs were analyzed. The estimates utilized allow the study of the programs at multiple life cycle stages of development. Most cost estimators in the federal government utilize Automated Cost Estimating Integrated Tools (ACEIT) for high value and complex programs. ACEIT is a family of applications that support program managers and cost/financial analysts as a tool for analyzing, developing, sharing, and reporting risk-adjusted cost estimates.

The objective of studying and analyzing the data was to establish statistics around the Contingency Reserve allocation and risk assumptions made by the programs historically. This helps when building new estimates, by determining the correct funding confidence levels at the different acquisition decision events. Also, it will give management and decision-makers, better tools to decide the level of

confidence on which to set the budget instead of opting to the 50% confidence by default, potentially helping to set a new standard for allocating risk at various acquisition decision events, including the early stages when creating the first (Rough Oder Magnitude) estimates.

For this study, only major acquisition (level 2 and 1) programs (from $300 million+ to over $1 Billion+ in costs) in the DHS Cybersecurity portfolio where evaluated.

RESEARCH RESULTS

The data spoke almost as immediately as the basic statistics where being calculated. The data validated some assumptions while providing new insights and questions. For the analysis of the data, different tools where utilized (Excel, Minitab, and Tableau for data visualization); The variable of interest in this study was the "Contingency Reserve" and the visualization of the data provided a dynamic way of asking and answering questions from the data. As the research dove deeper into the relations and interaction of the CR with the other variables, the value of the study became clear.

Table 1 displays some of the basic statistics that provided valuable insights like the fact that the Point Estimate was estimated on average at the 35% confidence level, that the average contingency of all programs was 3.52% and that the estimates had an average coefficient of variation (CV) of 12.85%.

Table 1

Sample of Basic Statistics

Variable	Total Count	N*	Mean	StDev	Variance	CoefVar	Sum	Sum of Squares
Point_Estimate_(BY)	34	0	2249	2179	4750063	96.93	76449	328648527
PE_CL%_(BY)	34	1	0.3503	0.0921	0.0085	26.30	11.5590	4.3203
50%_CL_(BY)	34	0	2327	2273	5168141	97.71	79105	354597021
CV_(BY)	34	0	0.1285	0.1835	0.0337	142.82	4.3679	1.6719
BY_Contingency_$M	34	0	78.2	121.8	14838.8	155.73	2659.5	697706.5
BY_Contingency_%_(50%CL-PE)	34	0	0.03515	0.04309	0.00186	122.57	1.19523	0.10328
BY_Contingency_(Mean-PE)	34	0	133.4	223.2	49816.9	167.37	4534.0	2248594.1
BY_Contingency_%_(Mean-PE)	34	0	0.04890	0.05706	0.00326	116.69	1.66257	0.18874
Mean_(BY)	34	0	2382	2333	5445137	97.97	80983	372580261

The data also spoke to how the different programs estimates behaved compared to each other. Some programs demonstrated to have unusually high variability within their estimates across time. Programs are expected to follow the cone of uncertainty as it relates to their transition throughout their acquisition life cycles, the data revealed that there was more contingency being applied at the beginning of the PLC starting with ADE 1 and moving forward the contingency reserve percentages were reduced. In ~~figure~~ Figure 3 it can be observed how the CR% allocation can vary between programs concerning the overall mean.

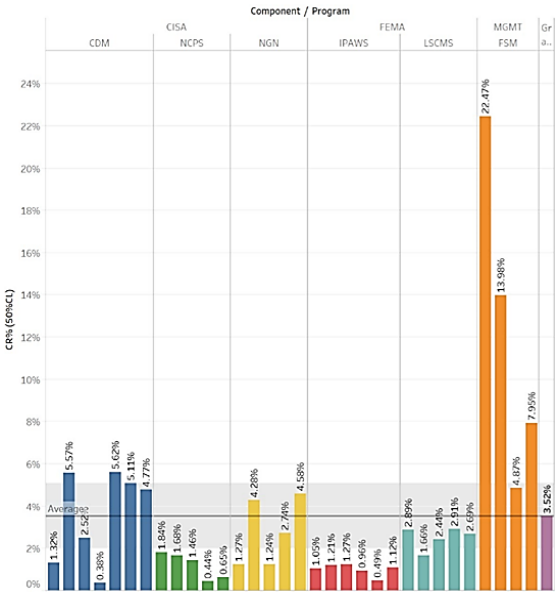

Figure 3

CR% By Component/Program

DISCUSSION

The Contingency Reserve will be the number of funds, or time needed above the point estimate to reduce the risk of overruns of a program. How much contingency reserve should be allocated to a program beyond the 50% CL will depend on how much a program cost growth an agency is willing to risk, to a confidence level that is acceptable to the organization.

The Air Force Cost Estimating and Assessment Guide states that a small Coefficient of variation (CV) of Lower than 15% is an indication of very optimistic ranges and that CVs greater than 35% may be an indication of unusually broad distributions. CV's in the 35% - 45% range is typical for software-intensive projects. The point estimate generally falls in the 15% - 30% confidence range. When the point estimate confidence level is lower than 15% this is often an indication that the CV may

also be very low (insufficient uncertainty). When the point estimate CL is greater than 35%, this is an indication that the point estimate may have some amount of uncertainty included [7]. Comparing this to the studied data, it was determined that the programs showed insufficient uncertainty with an average total CV of 12.85%.

The GAO cost estimating and assessment guide establishes the best practices for developing and managing capital programs and it states that cost distributions tend to be right-skewed because the mean of the distribution tends to fall between the 55% - 65% CL. Therefore, if it is decided to fund a program at the 50% CL, there is still a chance that the program will need additional funding because the expected value is higher [3].

One of the original assumptions made when conducting this study was that the components were not applying enough Contingency Reserves to their programs by allocating risk at the 50% CL by default; This was proven to be true with and the data revealed that 82% of the programs estimates had less than 5% CR; not enough room for a proper contingency reserve allocation when funding at the 50% CL in the resulting S-curve. Once the current state of CR% allocation was established and studied, assumptions to possible future scenarios were introduced as it was determined that the allocation of the contingency reserve at the 50% CL was not ideal. The data showed that the CR% would be better allocated when funding programs at the mean instead of the 50%CL, by doing so the average CR% would be raised to 5%.

Current guidance states that programs must use a 50% confidence interval as the basis for the objective cost with the Threshold being set up to 15% above the Objective cost parameter; However, the data showed that the cybersecurity portfolio of programs would have been better funded at the Mean instead of the 50% CL. This would have reduced the anxiety about success within budget, allowing them to have better provisions for unknown but likely to appear risks as the project progresses and it would help reduce the probability that they will have to explain overruns or rebase-line because they ran out of contingency reserve.

CONCLUSION

The proper and correct allocation of the Contingency Reserve ensures that a program's cost, schedule, and performance goals can be met. The analysis also communicates to decision-makers the specific risks that contribute to a program's cost estimate uncertainty. Without this knowledge, a program's estimated cost could be understated and subject to underfunding and cost overruns, putting it at risk of being reduced in scope or requiring additional funding to meet their objectives. Because each program is unique and so are its risks, there are no set rules as to what level of contingency reserve would be sufficient.

This paper served as the beginning of a much larger study into the historical use of the Contingency Reserve within the DHS portfolio of high-level acquisition programs. Further study will be invested in the different commodities of programs (IT, Ships & Aircraft, Facilities, etc.) to determine if the current guidance should be amended.

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