Methods and Challenges in Early Cost Estimating

Prepared by:

David Hull

Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE)

Arlington, VA 22202, United States

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Abstract.

Department of Defense (DoD) leadership is currently making decisions on acquisition programs much earlier in the system's lifecycle than they have in the past, and leadership demand for cost information to support these decisions is growing rapidly. Since its inception two years ago, the ODASA-CE Early Cost Team's primary mission has been to find ways to ensure that the cost information to support these early decisions is available and reliable.

Capability-Based Cost Estimating is a tool that in many cases can enable cost analysis for these early decisions. Although it has proven to be very helpful, capability-based cost estimating presents challenges. Where does an analyst start when they are asked to produce an early cost estimate when they do not have key information such as quantities or schedules? How can an analyst utilize what little information is provided in early capability documents to produce a lifecycle cost estimate?

This paper presents some atypical methodologies that can be used to extract the limited available information in early capability-based documents to develop an estimate. Examples from some of the early cost estimating efforts where the ODASA-CE Early Cost Team successfully used some of these methods will be provided. Furthermore, the paper discusses some challenges that still must be overcome as Capability-Based Cost Estimating continues to evolve.

1. Early Cost Estimating Background.

Approximately three years ago, our Early Cost Team at ODASA-CE[1] began addressing the challenges involved with Early Cost Estimating, and we are still going strong today. Department of Defense (DoD) leadership is currently making decisions on acquisition programs much earlier than they have in the past. Since its inception three years ago, our Early Cost Team's primary mission has been to find ways to ensure that these early decisions are cost-informed decisions.

When one talks about Early Cost Estimating, what exactly does "early" mean? Up until recently, most Army programs first surfaced for a decision at Milestone B, having had Milestone A effectively tailored out of the process. DoD leadership has recently started requiring Milestone A for many Army programs, and there will most likely be even more going through Milestone A in the future.[2] As programs move toward Milestone B, certain required documents, such as the Capability Development Document (CDDs) and the Cost Analysis Requirements Documents (CARDs), are developed and become available to the analyst. These documents are very helpful to the analysis process because detailed information can be extracted from them that can be utilized to produce cost estimates using conventional cost estimating methodologies. Prior to Milestone A,

[1] Office of the Deputy Assistant Secretary of the Army for Cost and Economics.
[2] The DoDI 5000.02 has been updated and includes guidance for acquisition programs going through Milestone A.

cost analysts would most likely not have access to CDDs, CARDs, or the detailed information that these documents typically include, and they will have to produce cost estimates using more unconventional methodologies. This distinction and the relative availability of data between cost estimating before Milestone A and cost estimating afterward allow us to define "Early" as "Pre-Milestone A."

Pre-Milestone-A Cost Estimating is a challenge due to the lack of programmatic and technical information that can be used to produce a cost estimate at that point in time. The few documents that may be available for analysis at this time are the Initial Capability Document (ICD) and results of the Functional Needs Analysis (FNA) or the Functional Solutions Analysis (FSA). An ICD normally identifies capability gaps and shows what capabilities a solution must have in order to fill those gaps. However, the ICD does not provide the level of detail that would normally be available in the post-Milestone-A world. When performing Post-Milestone-A Cost Estimating, an analyst should have enough information to utilize performance, technical, or physical variables, such as the maximum effective range of a weapon system, in a parametric Cost Estimating Relationship (CER). In the pre-Milestone-A world, the analyst may not know the system's required maximum effective range, and the only information they may have available is that the system must have the capability to shoot within certain scenarios or at certain threats. How does one estimate the cost of something when they only know its capabilities and nothing else? In seeking to answer this question is how the idea of Capability-Based Cost Estimating originated.

Capability-Based Cost Estimating is defined as using the capabilities of a system (preferably defined in an authoritative JCIDS capability document) to produce a cost estimate. Although it is intuitive to see how Capability-Based Cost Estimating would be useful in the Pre-Milestone-A timeframe, it is actually a distinct concept from Pre-Milestone-A Cost Estimating. Capability-Based Cost Estimating uses capability-based information to produce a cost estimate. Pre-Milestone-A Cost Estimating, on the other hand, uses all available information at that point in time; not just capability-based information. Performance information and technical parameters, if known, can be used with capability-based information during Pre-Milestone-A Cost Estimating. However, it is clear that Capability-Based Cost Estimating is a tool that in many cases enables Pre-Milestone-A Cost Estimating.

2. Early Cost Estimating Concerns.

Where does one start when they are asked to produce a Pre-Milestone-A Cost Estimate and they have no programmatic information on system quantities or schedules? How would one go about producing a Pre-Milestone-A Cost Estimate for something when they do not know exactly what it is that they are costing? Our Early Cost Team has had to deal with these questions while being involved with various Early Cost Estimating efforts over the last three years. We are finding that there is no single answer to either of these questions. As each new Early Cost Estimating effort presents itself, we actually find ourselves doing something a bit different and learning something new. Based on our

experience in this area, we have gathered some key lessons learned from our work-to-date.

The objective of this paper is not to dictate how to produce a Capability-Based Cost Estimate, but to show how one can be produced. The methods and methodologies in this paper led to some success for our team in the Early Costing scenarios with which we were involved. However, every Early Costing scenario will be different, and different scenarios may call for different analysis approaches. Analytical judgment will always be the biggest factor in determining how to produce any Early Cost Estimate. This paper will discuss methods and methodologies that have been used to develop a cost estimate when programmatic information such as quantity and schedule is not known. In addition, this paper addresses the issue of how to estimate the cost of something when done does not know the exact form of what it is they are costing. Additionally, this paper discusses some of the challenges associated with Pre-Milestone-A and Capability-Based Cost Estimating that our team has encountered over the last three years. The overall goal of this paper is to present readers with some ideas that can be used to produce a Pre-Milestone-A Cost Estimate.

3. Early Cost Estimates: Where to Start.

3.1. Getting Started When Little Programmatic Information Exists.

Cost analysts have come to expect that they will know a basic amount of programmatic information such as a system's description, quantities, and program schedule in order to produce a cost estimate. The typical way for estimators to get this information is to have access to a complete CARD and other documents that provide relevant programmatic information on the system for which we have to produce an estimate. How would one go about developing a cost estimate when these documents have not yet been produced and the information typically assumed to be available is not?

In most cases prior to Milestone A, there would not be a CARD or any other source to provide detailed system or programmatic information. Furthermore, in many Pre-Milestone-A cases, it is anticipated that the only documents that one would have access to are the ICD, FNA, and FSA. These documents will not give analysts nearly the amount of information that a CARD or other post-Milestone-A acquisition documents would give. These documents do not provide two of the most fundamental pieces of information that are used to produce most Life Cycle Cost Estimates (LCCE): quantities and schedule. Not only would one not have a good definition of what they have to cost, but they would not know anything about the prototype or production quantities, production schedules, or the fielding schedules of what is being estimated. This information on quantities and schedule is so fundamental to any cost estimate that analysts normally take it for granted and think that it would be impossible to produce a cost estimate without it. So, where does an analyst start when they are asked to produce a Pre-Milestone-A Cost Estimate and have no information on quantities or schedule?

One method that has worked for our Early Cost Team when starting a Pre-Milestone-A Cost Estimate has been to think about what the cost estimate will look like when it is complete. At first it may sound counter-intuitive to think about the estimate's end state in order to be able to start the estimate but how one plans on displaying the cost results can set the tone for the entire estimate. Cost analysts are so used to producing Life Cycle Cost Estimates that they tend to think that a total Life Cycle Cost format, such as the format in ***Figure 1*** is the only way to display cost estimates.

	BY08$M
RDTE	$386.5
Procurement	$17,083.7
O&S	$25,303.6

Figure 1: Traditional Display of Cost Results (Costs are Notional)

The main problem with this results format in the Pre-Milestone-A world is that it may be impossible to produce a traditional LCCE when there is no available information regarding system quantities or schedules. Instead of an analyst admitting defeat because they do not have the information they would like to have, they can change the rules. When conventional cost methodologies and results presentation are not getting an analyst anywhere, they may have to turn to unconventional tactics. The Pre-Milestone-A Costing environment is unconventional, so one can expect that methodologies and results presentation will not conform to normal expectations. A different way to display cost results provides analysts a means, which may not be appropriate when using more conventional cost result displays, to provide decision-makers with important cost information.

3.2. Potential Cost Results Displays and Early Cost Methodology Considerations.

One format used successfully by our Early Cost Team to present Pre-Milestone-A Cost results is displayed below in ***Figure 2*** (costs are notional).

	BY08$K
RDTE	Development Engineering Cost: $1,234.7 - $1,748.2 First Unit Prototype Cost: $928.3 - $1,003.4
Procurement	Non-Recurring Production Cost: $3,452.9 - $3,983.2 First Unit Procurement Cost: $424.5 - $502.3
O&S	Annual O&S Cost Per System: $32.9 - $45.2

Figure 2: One Potential Way to Display Pre-Milestone-A Cost Results (Costs are Notional)

The format in ***Figure 2*** does three important things. First, it provides a way to display costs without having to know anything about prototype quantities, production quantities,

production schedules, fielding schedules, learning effects, or rate effects. Second, it shows a cost estimate range (as opposed to a point estimate) in an effort to properly convey to decision-makers the risk associated with the relatively imprecise Pre-Milestone-A Cost Estimate. Third, it shows a level of detail that is reasonable for a Pre-Milestone-A Cost Estimate. The manner in which these costs are displayed in ***Figure 2*** warrants some discussion. Some of the costs, such as the RDTE and Procurement costs, may resemble certain types of costs such as Program Acquisition Unit Costs (PAUCs) or Average Procurement Unit Costs (APUCs), but that is not the case in this instance. This is an entirely different way of showing cost results from what has been done in the past.

In ***Figure 2***, the RDTE cost results are separated into two costs: a Development Engineering cost and a First Prototype cost. The Development Engineering cost is displayed separately because it is assumed that it is a non-recurring cost regardless of how many prototypes are manufactured. It may not be best to display one single RDTE cost per prototype because an observer might look at that cost and think that all they have to do is multiply that cost by the quantity of prototypes once that quantity is decided and they would have a total RDTE cost. This would not be the case because Development Engineering costs should be non-recurring and should not increase as prototype quantities increase. No matter how many prototypes are manufactured, the Development Engineering cost should stay relatively stable.

The first prototype RDTE cost is a fully-burdened cost that includes all contractor and government RDTE costs associated with manufacturing the prototype except for the Development Engineering costs that have been accounted for separately. Dividing the RDTE cost into a non-recurring RDTE cost and a recurring first prototype RDTE cost provides a way to display RDTE costs without having to know how many prototypes will be manufactured. It is also important to note that the level of detail that is displayed here is not broken down into the familiar detail found in the Army Cost Element Structure. The costs are simply broken down into a non-recurring cost and a first prototype RDTE cost. The first prototype RDTE cost can be broken down into two costs; the first prototype cost (which includes only contractor costs) and additional government RDTE costs (which include only Government costs). The first prototype cost includes contractor Systems Engineering/Program Management (SE/PM) costs, contractor Testing costs, and contractor General and Administrative (G&A) costs with fee as well as the Prototype Manufacturing costs. This prototype cost can be found by using analogous prototype data or by stepping up from a first unit production cost. The main difference here from typical cost estimating practice is in the comparison between a prototype cost and production unit cost. Normally, analysts would compare only the Prototype Manufacturing costs to Recurring Production costs, but many times, as was the case with a recent Milestone A estimate, data on contract prices for prototypes and production units is all they have been given. When having to deal with contract prices, analysts may have to end up comparing RDTE contract costs to Production contract costs, hopefully after being able to separate Non-Recurring costs from the Recurring costs, to come up with step-up or step-down factors. Then, in order to account for the additional Government RDTE costs such as Government SE/PM and Testing costs, analysts can use Budget

RDTE Forms (R-Forms) for analogous systems that can give them a cost factor of total RDTE cost for the analogous system to Prototype Contract cost.

The Procurement cost results in ***Figure 2*** are separated into Non-Recurring Production costs and First Unit Procurement costs for the same reasons that Development Engineering costs were separated from First Prototype RDTE costs. The First Unit Procurement cost is a fully-burdened procurement cost that is also broken down into First Unit cost (which includes only the contractor costs) and the additional Government Procurement costs. The First Unit cost can be found by analyzing analogous Procurement systems or by stepping down from a First Prototype cost. Then, in order to account for the additional Government Procurement costs such as Government SE/PM, Testing, and Fielding costs, analysts can turn to Budget Procurement Forms (P-Forms) for analogous systems that can be used to develop a cost factor of total Procurement cost for the analogous system to Production Contract cost. That factor can then be applied to the First Unit cost to arrive at a fully burdened First Unit Procurement cost.

The O&S cost results in ***Figure 2*** are displayed as Annual O&S Cost Per System. This method of displaying the results allows one to show an O&S cost without having to know the fielding schedule of the system. It is interesting to note that the Annual Cost Per System display is the format used by Selected Acquisition Reports (SARs). These costs can be estimated in a variety of ways including using historical O&S data on analogous systems and scaling those costs by Unit Production cost (or other relevant metric).

It is clear that some decision-makers may be uncomfortable with this display of cost due to their unfamiliarity with the format. This can be easily overcome by explaining that this format is used as way to display cost results when there is very little programmatic information available. Again, it is not the purpose of this paper to dictate specific methodologies or results displays. The purpose is to show that it is possible to develop cost estimates and display costs in situations where an analyst does not have typically available information such as quantities or schedules.

4. Develop a Cost Estimate in a High-Uncertainty Environment.

4.1. Using Capability-Based Cost Estimating to Produce a Cost Estimate.

When producing a Pre-Milestone-A Cost Estimate, it is often the case that a program of record has not been established, and the only information an analyst will most likely have will be in an ICD and possibly the Functional Needs Analysis (FNA) and Functional Solutions Analysis (FSA) results. These are typical capabilities documents that do not necessarily give a good description of what it is that must be estimated. How can one use what little information they have in an ICD/FSA/FNA to produce a Pre-Milestone-A Cost Estimate?

This is where Capability-Based Cost Estimating becomes an essential tool before Milestone A. When an analyst sets out to develop a cost estimate and the only information they have is in a capabilities document, they must base their cost estimate on

the capabilities found in that document. Our ODASA-CE Early Cost Team has found that the methodologies we select depend on the types of information available in capability documents. **Sections 4.2** and **4.3** discuss methodologies used in actual Early Cost scenarios over the past three years.

4.2. Dismounted Observer Targeting Scenario.

The first scenario is one in which the ICD was uncharacteristically detailed with more than just capability information. One could almost consider this scenario a best-case scenario. The Targeting System ICD described capability gaps in target location and target designation that were identified during Global War on Terrorism operations. ODASA-CE was asked to develop cost estimates for an AoA supporting this Targeting System's approaching milestone. The ICD identified that the solution to fill the capability gaps would have target location and designator capabilities. Generally speaking, target locator systems use a laser to determine the location of an enemy target. Target designator systems use a laser to designate a target for delivery of precision munitions. The ICD described this targeting system as having a nighttime target identification capability, a daytime target identification capability, a target location accuracy capability, a target designation capability, and an infrared (IR) marking capability. The ICD went even further into detail by providing desired performance parameters for each capability.

Performance parameters are not to be confused with capabilities. They are similar but not the same. For example, the ability of a weapon to shoot is a capability while the maximum effective range that the weapon can shoot is a performance parameter. Our team was lucky in this case to have both performance parameters and capabilities in the ICD. The ICD quantified many of the capabilities as performance parameters, and this is more detail than what is normally found in ICDs. It is not normal to see this level of detail until a Capabilities Development Document (CDD) is produced. Access to this much information this early was an asset, but there were several key challenges that required capability-based thinking to overcome.

In the end, the analogous capability dataset was used to produce a cost estimating relationship (CER) that utilized both capabilities and performance parameters from the ICD. The performance parameters of nighttime target identification range, daytime target identification range, and target location error had proven to be cost drivers and were used as quantifiable performance variables in the CER. The performance parameters of target designation range and IR marking range did not prove to be cost drivers, but the fact that a system had the capability to designate or IR mark was a cost driver. This meant that we could use these two capabilities as binary dummy variables having a value of one (1) if the system had the capability or a value of zero (0) in the system did not have the capability.

The method used to derive the dataset from which the CER was developed was visibly capability-driven. When developing a CER, all data points from which the CER is

developed should be analogous to the system that is being estimated. The main challenge with this AoA was that no current systems had all the capabilities that were required of the new targeting system. Some current systems had nighttime and daytime target identification capabilities, but no target designation capability. Some current systems had a target designation capability, but no nighttime or daytime target identification capabilities. Even the most analogous current system had nighttime and daytime target identification capabilities and a target designation capability, but had no IR marking capability. From a capabilities standpoint, our team had no data points that were exact analogues to the new targeting system. In order to bypass this obstacle, we decided to create combinations of various systems to form a capability set that represented the overall required capability of the new targeting system. For example, we would take a target location device with IR marking capability and combine it with a target designation device to achieve the same overall capability that the new targeting system was required to have, even though the systems we were combining were not specifically designed to work together as a single system. These combinations of current systems gave us an analogous capability dataset to work with in order to estimate a cost for the new targeting system.

As mentioned before, this was an atypical scenario and can certainly be considered a best case scenario due to how much detailed information was in the ICD. Normally, analysts would not have access to this much detailed information on a system during the Pre-Milestone-A timeframe. In this scenario, our team knew with some clarity what the system was that we were costing. However, the way in which we constructed the CER dataset and cost driver identification were two key places where capability-based thinking played a pivotal role. In the next scenario, we still had relatively detailed system information available to us, but there were no performance parameters listed in the ICD. Capability-based thinking had to be used in an entirely different way to produce a cost estimate.

4.3. Tactical Mobility Scenario.

This scenario is one in which the information in the ICD is more characteristic of what is typically seen. The ICD showed mobility and survivability capability gaps in light tactical vehicles. Our Early Cost Team was asked to verify and validate costs of a vehicle solution to the Tactical Mobility ICD. Again, we were able to tell from the ICD roughly what it was that we needed to cost, but not with any exactness. In other words, we had enough information to know that the solution was a tactical vehicle, but we did not have the technical or performance information like what one would find in a CARD. This situation called for some atypical capability-based thinking.

The ICD indicated that the solution would be a tactical vehicle that was survivable. From this, we knew that any analogous dataset would likely consist of armored (or otherwise equivalently protected) tactical vehicles. Moreover, two pieces of information came to our attention that helped shape our analytical approach. First, the ICD indicated that the solution should have the specific transportability capability to be externally transportable by a CH-47 model helicopter. Second, from previous work with tactical vehicles, we

knew that vehicle weight tends to be a major cost driver. We were able to use these two pieces of information to translate a capability into a technical specification. In order to be externally transportable by a CH-47 helicopter, a vehicle can only weigh a certain amount. We then assumed that the vehicle would weigh this maximum weight, based on the ICD survivability capability. Due to some additional schedule and material availability information known regarding the solution, we also assumed that the vehicle armor would be made of same type of armor used in current production environments as opposed to any lightweight composite armor that was not at an adequate level of development maturity.

Using a dataset of tactical armored vehicles and the maximum vehicle weight allowed for external transportation by a CH-47, we were able develop a CER based on vehicle weight. This is an instance where it may initially seem that the CER is not capability-based since the only variable is a technical specification variable. However, this is not the case. The technical specification variable was derived by turning the external helicopter transportability capability from the ICD into the technical specification of vehicle weight. Although using the capability alone from the ICD was a valid option, additional available system data allowed us to improve our estimate by leveraging the maturity of the Pre-Milestone-A system under consideration.

One of the lessons that our team has learned is that capabilities are often linked to technical and performance specifications, and if the situation and level of information availability permits, one can bridge this gap between capabilities and performance, using either or both to improve cost estimating. For example, mobility capabilities transition well to speed, shooting capabilities transition well to maximum effective firing range, sensing capabilities transition well to sensor range, transportability capabilities transition well to weight and size, and target location capabilities transition well to metrics such as target location error and range.

Another important lesson to take away from this scenario is that there are often many assumptions that must be made in order to produce a Pre-Milestone-A Cost Estimate. Sometimes making assumptions like these is uncomfortable for cost analysts. It may be helpful to remember that analysts are used to making assumptions for post-Milestone-A Cost Estimates when information is lacking. In the pre-Milestone-A world, it makes sense that more assumptions may have to be made because there is often much less information available but analysts should be careful about over-specifying or making too many assumptions.

The objective of discussing these two scenarios was to provide some insight into how Capability-Based Cost Estimating can been used to produce a Pre-Milestone-A Cost Estimate. The first scenario involved an ICD with detailed information, and the other, and ICD with less detail. With the DoDI 5000.02 requiring cost estimates at Milestone A, future Early Cost Estimating scenarios may provide significant challenges. The next section on Early Cost Estimating challenges will discuss some that can be expected in the not-too-distant future.

5. Early Cost Estimating Challenges.

5.1. Cost Estimates for Portfolio Analysis and Capability-Based Planning Scenarios.

One anticipated Early Cost Estimating challenge would be a scenario where analysts may be asked to produce costs based strictly on capabilities alone. Such a scenario could easily arise as DoD moves more toward portfolio analysis and capability-based planning. Portfolio analysis and capability-based planning are more capability-focused, whereas the current process is more materiel focused. Even some ICDs point toward a particular materiel solution that would alleviate certain capability gaps. In the two scenarios described earlier, it was evident that one ICD was pointing toward some sort of targeting system as a solution and the other ICD was pointing toward a tactical vehicle solution. In those examples, there was not much ambiguity as to what the solution was going to be. As was seen in the tactical mobility scenario, even though we did not have a description of the tactical vehicle we were supposed to cost, we nonetheless knew that we were estimating the cost of a tactical vehicle. As DoD moves more toward portfolio analysis and capability-based decision making, analysts may be asked to provide costs for capabilities where it is very ambiguous as to what the solution will be.

A very simple example of such a scenario would be someone asking an analyst to estimate the cost of the capability to move from one point on one side of a river to another point on the other side of the river. In reality, these types of scenarios would be much more complex, but this simple example illustrates the point. In this example, the analyst knows they must provide a cost for something with the capability to move across the river but they are not given any insight into whether they fly across it in an aircraft, drive across a bridge in a vehicle, or cross the river in some type of watercraft.

Although it is certainly possible to provide a general cost of the capability to maneuver across water, an alternative way to solve this problem is to break the problem down into different courses of action and estimate the cost of each alternative (which equates to showing how much it would cost to fly over the river, how much it would cost to cross the river in a vehicle, et cetera). Essentially, this method would provide a cost for the capability to move across the river by showing the costs for the various solutions that would achieve that capability. In addition, if appropriate, the analyst may choose to develop these costs by translating capabilities such as ground maneuver into performance parameters such as vehicle speed or technical parameters such as vehicle weight.

However, as mentioned before, there may be scenarios such as this that may provide even sparser information, and require analysts to produce costs based strictly on capabilities. Producing a cost estimate in these cases will prove to be very challenging, very uncertain, but very possible.

5.2. Capabilities-Only Scenarios.

In cases where an analyst only has a capability set to work with, one way to develop a cost estimate is to use what is known as a "cost per capability" tool. The Cost Per Capability Tool currently being deployed through ODASA-CE solves systems of linear equations within an Excel Solver framework. A simple example of this would be finding the cost for three specific capabilities such as maneuver by ground, line-of-sight fires, and battle command communications. In this example, an analyst would need to find at least three systems that have one, two, or all three of these capabilities, as well as the respective costs for those systems in order to find a cost per capability for the three capabilities. This type of methodology would produce a very rough cost estimate per capability, but it is starting point and could be used in early, "quick-turn" decision-making. An analyst would need to clearly communicate the level of uncertainty associated with the estimate to those using it to support decision-making.

The aforementioned Cost Per Capability Tool is soon to be released by ODASA-CE via the Capabilities Knowledge Base (CKB). It will be able to aid in the development of capability-based estimates for scenarios far more complex than the example provided above[3]. As future Early Cost Estimating opportunities present themselves, our Early Cost Team will continue to refine current methods and develop new methods to tackle challenging portfolio analyses and capability-based planning scenarios.

5.3. Software Capability-Based Cost Estimating.

Another challenge is estimating the cost of software in the Pre-Milestone-A timeframe. Post-Milestone-A Software Cost Estimating continues to be a challenge, and pre-Milestone-A Software Cost Estimating is no different. Most elements of the scenarios described in this paper were hardware cost estimating examples. Hardware tends to be easier to deal with because it tends to have a direct relationship between cost and performance/capability. Intuitively, one would think that the same reasoning should apply to software. If a software solution has more capability it should cost more. This reasoning may very well be correct, but the lack of software development data is a debilitating challenge. The Early Cost Team has been presented with opportunities to use Capability-Based Cost Estimating to develop a cost estimate for software systems. So far, our preferred approach has been to identify software systems that are analogous in capability and mission, which employs the capability-based analysis approach. However, in some cases, due to the lack of software development data, we have resorted to using subject matter expert (SME)-provided lines of code data with adjustments for code growth in a similar fashion as in post-Milestone-A Software Cost Estimates. Nevertheless, we have not lost hope. As more software development project data becomes available, our Early Cost Team is working to find better ways to use Capability-Based Cost Estimating to produce Pre-Milestone-A Software Cost Estimates.

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[3] C. Sibert, 'Capabilities Knowledge Base (CKB) Analysis Tools and Applications', 2009.

6. Summary.

Again, the overall objective of this paper was to present some ideas that can be used to produce a Pre-Milestone-A Cost Estimate and how Capability-Based Cost Estimating can be used to produce that estimate. This paper has also discussed some of the challenges that analysts are facing. Pre-Milestone-A and Capability-Based Cost Estimating are by no means simple processes. However, our Early Cost Team has found that developing these estimates is necessary due to leadership demand for cost information much earlier in a system's acquisition life cycle. Leadership will make early decisions with or without input from cost analysts, and in order for them to make cost-informed decisions, they need cost information. Providing leadership with some cost information, even with significant uncertainty associated with it, is better than providing them with nothing. As long as analysts inform decision-makers of the risk and uncertainty involved with the costs they produce during a Pre-Milestone-A timeframe and that the cost estimates will evolve as more information becomes available, they have done their job.

POC: David Hull
Operations Research Analyst, ODASA-CE
David.Hull@hqda.army.mil
(703) 601-4124
DSN 329-4124

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