Developing a Milestone-A Analysis of Alternatives Cost Estimate

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Abstract

Department of Defense (DoD) leadership is rigorously evaluating acquisition programs much earlier in the system's lifecycle than they have in the past due to the increased scrutiny of defense funding. This in turn greatly increases the demand for cost information to support these early programmatic decisions.

The ODASA-CE Early Cost Team recently estimated the life-cycle costs for an intellectually exciting and challenging Analysis of Alternatives (AoA). This analysis, which was of high interest to leadership, was to be completed in a much shorter period of time than normally expected. Furthermore, material solutions from multiple services were included within this AoA. Where would you as the analyst begin when asked to produce this early cost estimate knowing that key information such as schedules was not available? How would you define or scope the boundaries of the analysis? What data might you collect or methodologies might you investigate?

This paper discusses how this early cost estimate, which was approved by the Joint Study Advisory Group (JSAG) and made the Army's official cost position, was developed. Specifically, the atypical cost methodologies as well as the results presentation style that was utilized are presented. The lessons learned as a result of this effort are also discussed.

I. Recent Policy Changes and Resulting Challenges

The DoD's decision-making process is changing. The 2006 Quadrennial Defense Review (QDR) report called upon senior departmental leaders to "better integrate the processes that define needed capabilities, identify solutions, and allocate resources to acquire them in order to enable corporate decision-making that cuts across traditional stovepipes". In response to this guidance, DoD leaders have revised key guidance and instruction such as the DoDI 5000.02 to make mandatory early decision points and analysis such as the Materiel Development Decision (MDD), Milestone-A, and Milestone-A AoA. Prior to this process change, most Army programs bypassed Milestone-A and first surfaced for a decision at Milestone-B. The new acquisition process as detailed in the DoDI 5000.02 is shown in ***Figure 1*** below.

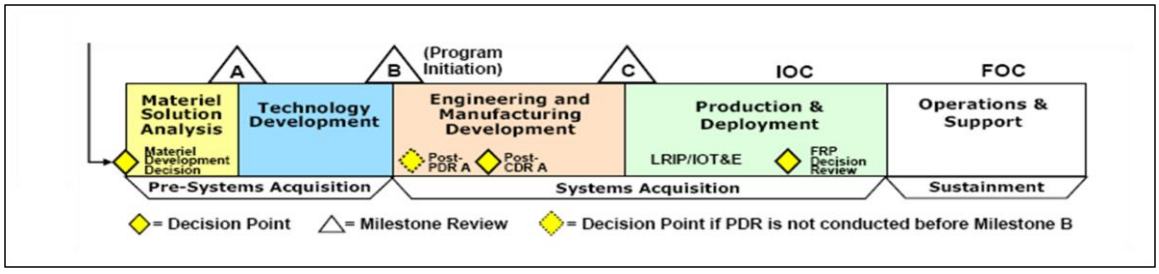

Figure 1: Acquisition Process as Defined Within the DoDI 5000.02
(Source: Department of Defense Instruction 5000.02 Dated 08 December 08)

II. Analysis of Alternatives

An AoA is a key element of the Defense acquisition process. It analyzes a spectrum of solutions to fill a set of identified capability gaps. Each alternative is analyzed and rated not only based on its military utility but also its cost effectiveness. An AoA is used by senior leadership to debate and assess a program's necessity, desirability and affordability. The most common AoA is conducted in the Milestone-A timeframe before an acquisition program is established[1]. The unique challenges associated with conducting a Milestone-A costs analysis are discussed in the following section.

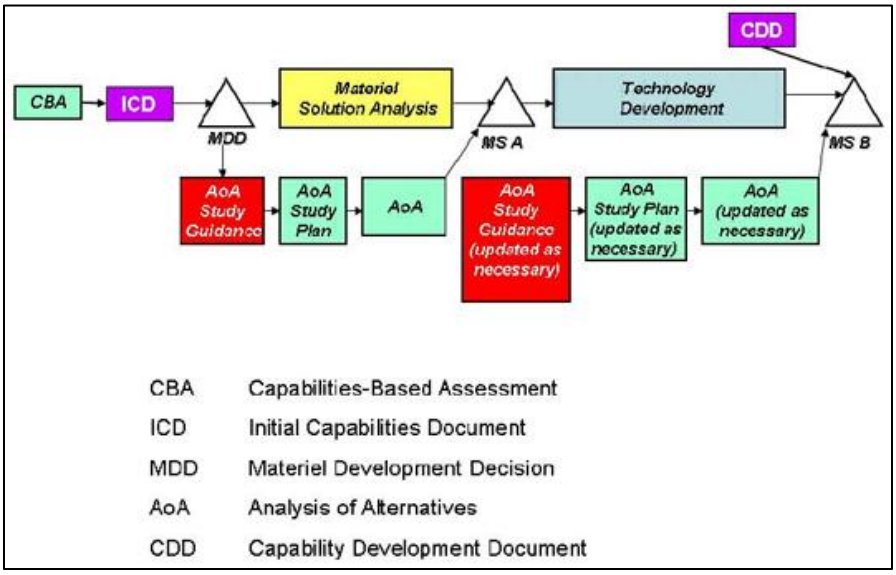

Figure 2: The AoA within the Defense Acquisition Management System (Source: Defense Acquisition Guidebook Dated 19 March 10)

III. Milestone-A Cost Analysis Challenges

The push for earlier investment decisions strongly impacts the DoD cost and analysis communities. Although costs are being considered earlier, the data traditionally used in cost estimation such as quantities, schedules, and acquisition strategy is typically unavailable at Milestone-A. Additionally, there is often not a program office available to support cost estimating or data inputs.

Prior to Milestone-A, system definition is limited. Systems typically exist as little more than concepts. Pre-Milestone-A systems (or capability sets) are undergoing a period of refinement and exploration that will be continued through Milestone-A and beyond. Since the level of definition associated with these systems/solutions is so imprecise, pre-Milestone-A cost analysis has inherent complexities and challenges as analysts and cost estimators are expected to cost programs that are not fully understood.

[1] Defense Acquisition Guidebook, 19 March 2010.

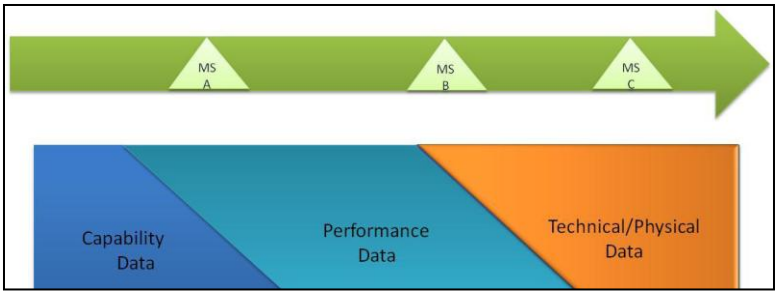

Figure 3: Cost Analysis Data Progression

IV. Case Study: Integrated Air and Missile Defense (IAMD) AoA

Background

The Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE) was tasked with conducting the independent cost analysis for the IAMD AoA in December 2008. As part of this tasking, it was requested that the cost analysis for this AoA, which consisted of four alternatives, be completed by April 2009. Thus, the cost analysis team was presented with quite a challenge – determine the full life-cycle costs for four alternatives within a four-month timeframe.

As previously stated, there were a total of four alternatives to be evaluated. As is standard in these types of analyses, one alternative was a baseline or status quo. This alternative consisted of fielded and/or funded systems and technology. The second alternative to be considered was an enhanced status quo that would require an additional (fielded) system to be integrated into the baseline alternative. The third alternative to be considered was the enhancement of a recently fielded system. Finally, the fourth and final alternative was a new material solution.

Analysis Steps

1. Project Familiarization

Much of the early analysis time spent by the ODASA-CE team was spent on defining the analysis objectives; the composition of the alternatives to be considered; and the level of capability enhancement required and/or feasible for each alternative. The team's first step was to obtain and review all available documentation. Existing analysis or specifications such as the results of the Functional Needs Analysis (FNA), the Functional Solutions Analysis (FSA), and the Initial Capabilities Document (ICD), all of which should be available pre-Milestone-A, are usually extremely beneficial. In addition to the available documents listed above, the AoA study guidance and plan were also reviewed in detail.

Another key step when beginning the cost analysis as a part of the Milestone-A AoA team is to confer with members of the other functional areas. Of particular importance are the analysis development and effectiveness analysis components. In general, efforts among all team members must be well-integrated. Since Milestone-A cost analysis most often relies on capability and performance data for its effective execution, inputs from the engineering, simulation/modeling, technical viability, and effectiveness analysis members is crucial[2].

[2] Draft Army Cost Analysis Manual, 15 July 2009.

The team worked closely with system engineers as well as other AoA team members to obtain and review necessary system architecture diagrams. These diagrams provided invaluable insight into the various systems contained within the four alternatives. The team also worked closely with the alternatives architect to develop simplified alternative architecture diagrams. These simplified diagrams captured the salient differences among the alternatives and provided an indication of the integration effort to be completed within each[3].

2. Cost Driver Identification

The team then worked to identify the cost drivers for the alternatives within this analysis. These cost drivers were composed of capabilities and/or performance parameters that drive system cost. There were two critical factors needed for the team to be able to identify these. First, the team needed to have a very good understanding of the four alternatives as well as the numerous systems contained within them. This knowledge of the alternatives was obtained during the initial project familiarization as detailed previously. The second factor was the identification and use of subject matter experts (SMEs). The subject matter and engineering expertise that the team received was critical to its success.

3. Data Collection

The body of data that the cost team desired to collect was directly based on the cost drivers identified previously. Not only was system cost data collected, but also schedule, software, and relevant performance/technical data. This data was collected for both systems included within the body of systems under consideration as alternatives, as well as system analogues that were similar, but not officially a part of any alternative. There were several authoritative DoD data sources from which the team was able to obtain the majority of this data. Data sources used included Program Office/Program Executive Office-sourced data such as Cost Analysis Requirements Documents (CARDs); Selected Acquisition Reports (SARs); and budget exhibits.

In addition to the data sources listed previously, a data call was also issued to program offices and SMEs. This data call was utilized to collect any remaining data that could not be obtained from the previously identified sources. When issuing a data call it is critical to precisely identify the key data elements to be collected. Unfortunately, the more demanding (i.e. larger) the data call is, the lower the response rate most likely will be. Thus, it is important to strike a balance between the body of data desired in an ideal situation and the data call magnitude that will yield the most comprehensive response.

Data collection is a time-intensive effort, especially in the pre-Milestone-A timeframe. However, it is critically important as data collection and data availability tend to drive the selection of methodologies within cost estimates due to the more constrained data environment. Methodology formulation often cannot begin until the majority of the data is collected. Thus, it is often beneficial to begin data collection prior to or in parallel with the definition of the AoA alternatives. Although this is not ideal (since knowing details about the various alternatives provides more insight into cost drivers), it is often necessary to meet AoA project deadlines.

[3] DASA-CE IAMD Independent Cost Analysis Report, 16 April 2009.

4. Methodology Development and Execution

The selection of cost methodologies at Milestone-A depends heavily upon what cost drivers have been identified, what the defined alternatives consist of, and the quality and quantity of data collected in the previous steps. As each system/capability set being estimated is unique, each Milestone-A costing approach will be unique, in that it must be adapted to that particular system's data availability, capability set, and cost drivers. However, for an AoA, it is important to use similar or identical methodology as well as common ground rules and assumptions across all alternatives being compared whenever possible. This consistency ensures true comparability of the alternatives and allows for quality decision-making.

Since the alternatives to be considered in a Milestone-A AoA typically are largely conceptual; do not have descriptive documentation such as a CARD accompanying them; and are not under the management of a program office, developing cost estimates at a detailed cost element structure (CES) level will likely require highly-detailed assumption-making that is not appropriate. Costs tend to be estimated at a major appropriation level largely due to data availability.

The methodologies used to develop the IAMD AoA independent cost estimates are described in the following sections. It is important to note that consistent methodologies as well as ground rules and assumptions were applied across all of the alternatives. The costs for this AoA were estimated and presented at the major appropriation level.

a. Research, Development, Test, and Evaluation

For the IAMD AoA, integration, test, and systems engineering within the Research, Development, Test, and Evaluation (RDT&E) appropriation was central to the system's timely delivery and crucial to program success. Therefore, two different approaches were taken and cross-checked to ensure the accuracy of this portion of the cost estimate. These two approaches were (1) the System Interdependency Model in partnership with OSD(AT&L) and Technomics; and (2) Capability-Based Software Development analysis. After ensuring that the methodologies and results did indeed validate one another, the results from the System Interdependency Model were selected for inclusion within the final AoA results.

The System Interdependency Model leverages the idea that system complexity and interaction with other systems/components is a key development cost driver. One way of capturing the complexity of system interdependency is using a graph theory approach – by capturing complexity using nodes and links. This model leverages DoD Architecture Framework (DoDAF) artifacts (specifically the Operational View-2 and System View-6) to convert systems to nodes/edges representations. A node is defined as an element of architecture that produces, consumes, or processes data. Nodes can be either send, receive, or send/receive nodes. A link is defined as a representation of the physical realization of connectivity between nodes. Link (or edges) can be unidirectional or bidirectional. Analysis and collaboration with system SMEs allowed for accurate graphical representation of the effort associated with each IAMD alternative.

Parallel to the System Interdependency Model, a Capability-Based Software Development methodology was generated for the AoA. To cost the additional software development needed to add functionality to each of the systems composing the alternatives, the software team devised a

method of determining an estimate of the amount of code needed by each program to generate the functionality. Current source lines of code (SLOC) counts were obtained for several fielded programs, as well as the projected SLOC counts for the new start alternative. The software team worked with the SMEs to determine the additional functionalities needed from the component programs of each alternative for the alternative to function as defined. A range of software productivities were used to represent the range of possible software complexities.

b. Procurement

Procurement cost analysis for the four alternatives consisted of gathering actual costs for existing hardware and adjusting for complexity for alternatives where additional development augmented the resulting hardware to be procured. Since a portion of the new start alternative hardware had not yet been procured under any Army effort, analogous hardware pieces were identified and adjusted for complexity. In addition, each alternative was consistently burdened to account for government non-recurring effort, systems engineering, systems test, program management, training, data, and fielding. Although individual system costs were calculated, total procurement costs were presented at a Composite Battalion (BN) level as specified in the AoA study plan.

c. Operations and Support

Operations and Support (O&S) estimates across the four major alternatives included costs for repairable and consumable parts; end item supply and maintenance; petroleum, oil, and lubricants; software maintenance; systems engineering and program management; and other government burden. A 20-year life cycle was assumed, and O&S strategy was based on that of a close analogue. An annual software maintenance factor based on several ODASA-CE studies was also applied. Disposal cost was also calculated and included for each alternative.

d. Risk Analysis

Risk analysis is an important element of any cost analysis result. It is especially important to note that a pre-Milestone-A point estimate is not very informative on its own. This point estimate must include a risk analysis or a cost range to capture the associated uncertainty.

A useful type of risk analysis during the pre-Milestone-A timeframe is schedule risk analysis. The IAMD AoA had an Initial Operating Capability (IOC) and later milestone (Milestone-B, C) requirements targets. The risk associated with these targets was assessed by looking at the actual schedules of analogous systems/programs. The format of the schedule risk analysis performed as part of the IAMD AoA (values notional) is shown in ***Figure 4.***

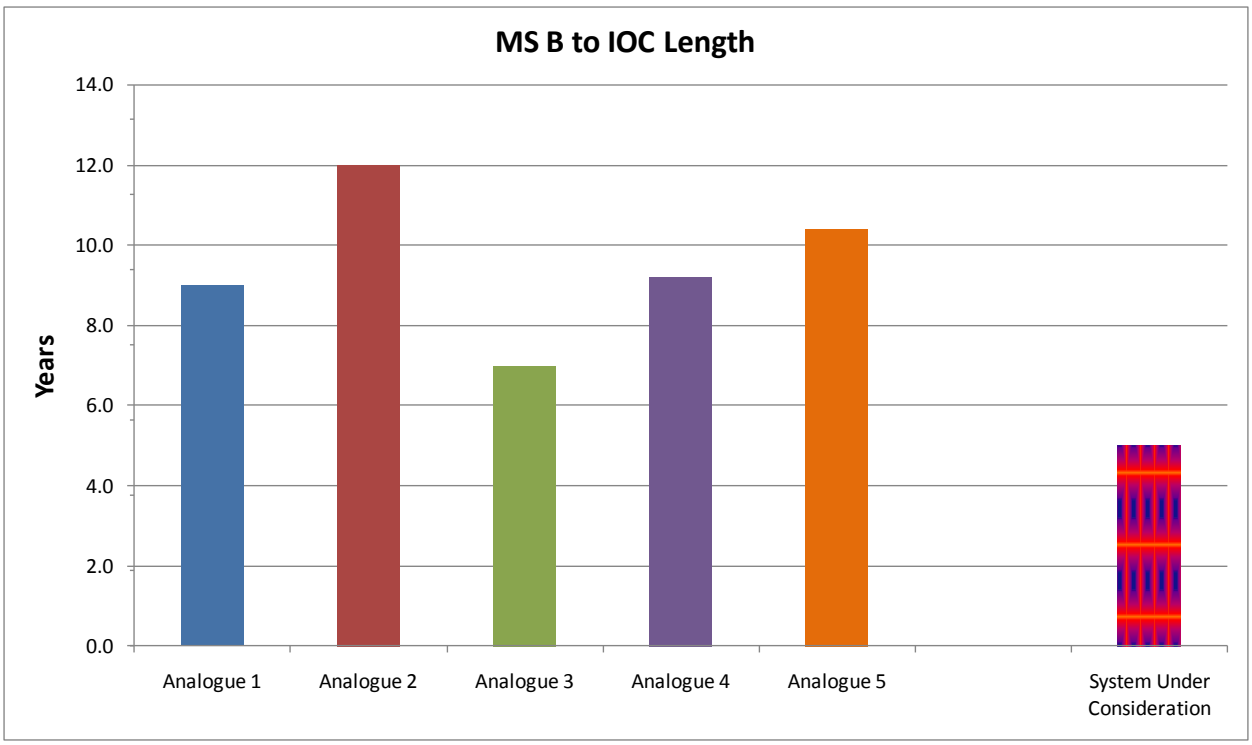

Figure 4: Sample Schedule Risk Analysis for AoA (Notional Values)

5. Documentation and Presentation of Results

As discussed previously in step 4, the alternatives to be considered in a Milestone-A AoA typically do not allow for cost estimates to be developed at a detailed cost element structure (CES) level due to a lack of data/definition. Instead, results for pre-Milestone-A cost estimates often take a form similar to that shown in ***Table 1***, which is the output format utilized for the IAMD AoA (cost values notional). Costs were displayed at a major appropriation level and also displayed as ranges, in order to communicate the risk and uncertainty associated with these estimates.

$M (2008)	Base Case	Alternative 1	Alternative 3	Alternative 4
RDT&E *(Total Cost)*	$ 10.1 – 25.7	$ 628.9 – 693.4	$ 176.1 – 254.2	$ 1,456.6 – 1,640.9
Procurement *(Total Cost for 15 BN)*	$ 257.1 – 270.2	$ 1,247.6 – 1,281.8	$ 725.5 – 756.8	$ 1,442.31 – 1,510.1
O&S *(Total Cost for 15 BN)*	$ 738.6 – 751.8	$ 2,812.0 – 3,032.7	$ 1,752.0 – 1,878.0	$ 4,243.0 – 4,664.0
Total Costs	**$ 1,005.8 – 1,047.7**	**$ 4,689.4 – 5,007.9**	**$ 2,653.6 – 2,889.0**	**$ 7,141.9 – 7,815.0**

Table 1: AoA Cost Results with Risk Ranges (Notional Values)

V. Conclusions and Future Pursuits

The methods and methodologies discussed in this document led to the successful completion of the IAMD AoA. The early cost estimate was later approved by the JSAG and made the Army's official cost position. However, it is important to note that every pre-Milestone-A project 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.

Since the level of definition associated with pre-Milestone-A systems/solutions is so imprecise and data is often very scarce, cost analysis at this point in time has inherent complexities and challenges as analysts and cost estimators are expected to cost programs which neither they nor the interested parties fully understand. Faced with decreasing funds and increasing funding scrutiny, DoD and Army decision-makers must make investment and programmatic choices early. Although some early decision-making in the past has not been cost-informed, leadership is now requiring cost analysis to inform strategy. Since early investment decisions must be cost-informed, the need for quality pre-Milestone-A cost analysis is not only critical within the analysis community, it is also critical to the success of early acquisition decision-making in general.

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