PRE-MILESTONE A COST ANALYSIS: PROGRESS, CHALLENGES, AND CHANGE

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The natural law of inertia: matter will remain at rest or continue in uniform motion in the same straight line unless acted upon by some external force.

Clement W. Stone

After three years of parallel research and application efforts aimed at enabling pre-Milestone A cost analysis, the time investment has produced dividends of progress and lessons learned for a team of Army researchers. Clearly, early acquisition investment decisions must be cost-informed, and the demand for this early cost information is growing. Although concrete tools are being developed to enable the analysis to support early investment decisions, it will not be achievable without an analysis culture with the policy, procedure, and willingness to develop and/or accept cost estimates that are less precise than those developed at Milestone B or Milestone C. Making early analysis a reality will require large-scale, department-wide culture change within and around the analysis community.

Keywords: *Pre-Milestone A, Cost Analysis, Acquisition Process, Joint Capabilities Integration and Development System (JCIDS), Analysis of Alternatives, Capability-Based Cost Analysis, DoDI 5000.02, Concept Decision*

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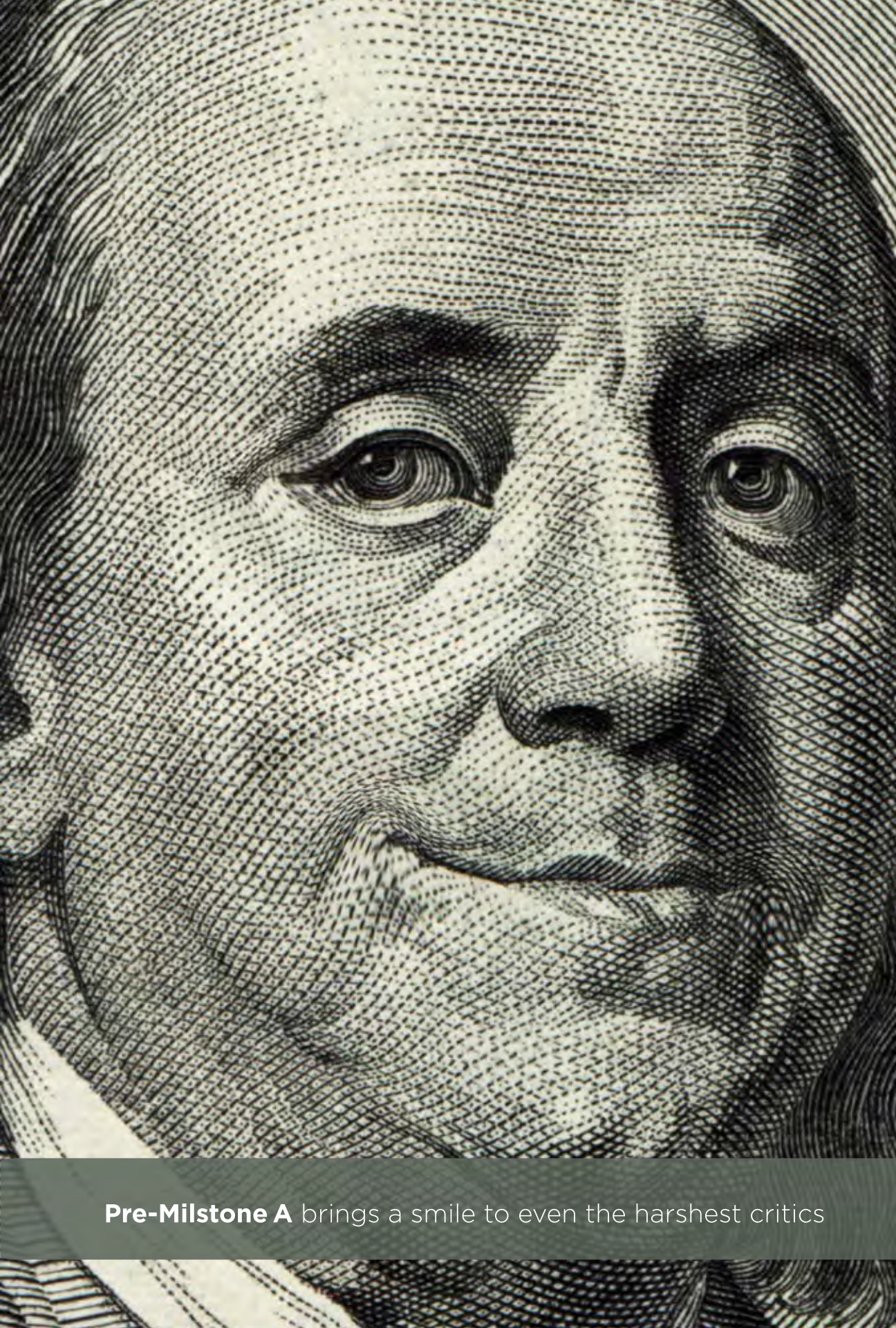


Pre-Milstone A brings a smile to even the harshest critics

Although Pre-Milestone A cost analysis is a relatively unfamiliar concept in defense analysis, its application is increasingly being researched and leveraged by a team of Army analysts at the Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE). Simply stated, a cost analysis aims to inform the decision-making process with specific types of information, namely measures in monetary terms of willingness to pay for a change by those who will benefit from it, and the willingness to accept the change by those who will lose from it. After three years of parallel research and application efforts, the team's time investment has produced dividends of progress and lessons learned. Clearly, early acquisition investment decisions must be cost-informed; and now more than ever, the demand for this early cost analysis information is growing.

But how can cost estimates be developed so early with so little system definition? Three major elements enable pre-Milestone A cost estimating. The first is an analysis framework that can make use of qualitative capability data (along with any physical, technical, and performance data available at that time) to produce a cost estimate. The second is a cumulative high-level cost data source that links systems to their capability sets. The third is an analysis culture with the policy, procedure, and willingness to develop and/or accept cost estimates that are less precise than those developed at Milestone B or Milestone C.

The first element, the capability-based analysis framework, has been developed and is being continuously refined and applied under the ODASA-CE internal research efforts (Roper, 2007a). The second element, the high-level capability mapping coupled to cost data, has been developed, populated, and is growing as more data become available (Roper, 2007b). The third element, however, is one that involves more than mere research and data collection. It requires large-scale, department-wide culture change within and around the analysis community. Clearly, without this third element, an ample supply of elements one and two alone will not enable capability-based, early cost estimating.

Observations and Lessons Learned

As a result of the 2004 Quadrennial Defense Review (QDR) emphasis on earlier investment decision making within the department, OUSD(AT&L) initiated the Concept Decision Experiment (2006-2008). This trial process took four pilot *capability sets* through a Concept Decision investment decision, where the key innovation was that the three key department stakeholders (or *Tri-Chair*)—acquisition, resourcing, and requirements—participated in the decision forum and committed (from their respective lanes) to whichever alternative(s) was selected.

An analysis process leading up to this event—the Evaluation of Alternatives (EoA)—supported the Concept Decision. It was similar to what is known as an Analysis of Alternatives (AoA) within DoD, except that it was broader, less granular, and included non-materiel solutions analysis. The evaluation and selection of an alternative was to be cost- and risk-informed, and coupled with some measure of how well the alternative filled the capability gap.

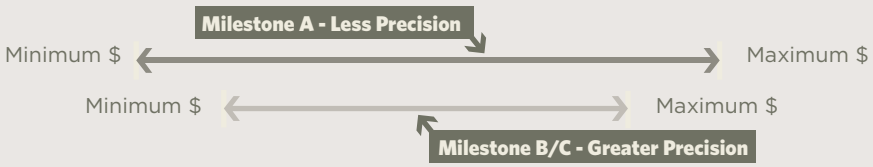
One of the main objectives of the Concept Decision Experiment was to enable early concept decisions that evaluate a trade space of materiel and non-materiel alternatives to fill capability gaps. A desired outcome of this early investment decision making is more stable defense acquisition programs. Although the Tri-Chair Concept Decision/EoA model was not adopted, some sweeping acquisition reform measures resulted from the experiment. Up until that point, most materiel solutions in the acquisition cycle were not required to be reviewed until Milestone B, effectively tailoring out the acquisition entry point and Milestone A.

In the aftermath of the Concept Decision Experiment, the Concept Decision point was recast as the Materiel Development Decision (MDD), a mandatory entry point to the acquisition process. At the MDD, the Milestone Decision Authority (MDA) determines to which milestone the solution/capability set proceeds. A clear and already evident result of this change is that many more Milestone A analyses are deemed necessary for solutions proceeding through the acquisition process. The AoA requirements remain relatively unchanged (from an analysis character point of view); however, due to the increased incidence of early-analysis Milestone A's, the use of AoAs has become much more prevalent. These changes were all formally instituted through the Department of Defense Instruction (DoDI) 5000.02 revision in December 2008.

PRECISION CONSIDERATIONS AT MILESTONE A

Intuitively, the primary focus of the ongoing Army research is how to enable early cost analysis (and its context). One of the terms used to describe the cost analysis required for an AoA at Milestone A is rough order of magnitude or *ROM* (DoD, 2006). However, the term ROM is problematic in that it has a well-understood mathematical definition that does not apply to the common DoD use of the term. A more accurate way to characterize cost analysis at or before Milestone A is to observe that the estimate range (indicating the range of probable costs) would be wider due to reduced system definition and greater uncertainty, as shown in the Figure. To date, no comprehensive effort is ongoing to characterize the form and expectation of pre-Milestone A analysis; therefore, great diversity in interpretation prevails across the department.

FIGURE. IMPACT OF SYSTEM MATURITY ON COST ESTIMATE RANGES



Probabilistically speaking, any one point estimate has a zero percent chance of being correct. As any cost analyst will confirm, risk analysis is an important element of any cost analysis result. On its own—and important to note—is that a pre-Milestone A point estimate is not very informative on its own—it must include a risk analysis or a cost range to capture the uncertainty associated with the estimate. As we add precision by adding system definition and/or analysis resources, our certainty around the associated point estimate will narrow. Intuition indicates that the range around the point cost estimate will narrow as we move from Milestone A to Milestone B to Milestone C (see Figure).

One analyst might believe a pre-Milestone A estimate is a range estimate based on one or more variables that gives a reasonable level of confidence. Another might believe it to be very similar to a Milestone B cost estimate (filling the many data gaps with assumptions), with the ability to perform detailed variable *what-if* drills. Clearly, an unambiguous definition is needed of what a pre-Milestone A estimate is and what level of analysis is considered acceptable. At or before Milestone A, if the system concept is at the level of maturity expected at that time (likely not well-defined), it would seem that the analysis should be something appreciably less detailed than at Milestone B. In fact, the level of system definition required to build a detailed cost estimate may not exist, or may require extensive *creative* assumption-making that may not be appropriate. Moreover, if the intent is to provide a way to distinguish between alternatives to inform prudent investment decisions, then a less precise estimate, coupled with risk ranges and measures, may be exactly what is required.

ENABLING DEPARTMENT-WIDE, CAPABILITIES-BASED COST ANALYSIS

Pre-Milestone A decision making often occurs in a data-poor environment. Prior to Milestone A, requirements or desired capabilities are known, but additional information is limited. Often, only general solution-type information is available. For cost analysis techniques to be relevant prior to Milestone A, they must take into account all available information. One method of dealing with this data-poor environment is to engage in capability-based cost analysis.

Capability-based cost analysis begins with the idea that system capabilities are related to system cost. Once a link between capabilities and cost is established for existent systems, this mapping can be used to estimate the cost of future systems based on their capabilities. If additional information is known or becomes available, it can be used to improve the estimate's accuracy. Capability data join physical, technical, and performance data as relevant data sources and bases for analysts' estimates.

Capability-based cost analysis and pre-Milestone A cost analysis are two distinct concepts. While the necessity of cost analysis during pre-Milestone A often requires the inclusion of capability-based cost analysis techniques, capability-based analysis has utility after Milestone A has come and gone. Capability-based cost analysis is relevant at all stages of a system's life cycle; it can aid in identification of analogous systems and methodology development whenever applicable and appropriate. To date, the focus of capability-based analysis has been to provide system acquisition costs. However, capability-based cost estimating can also derive costs for maintenance or disposal. Two main advantages of capability-based cost analysis are that it can be done with limited data and that it provides a relatively intuitive output. At times, when minimal information is available, capability-based analysis enables the rapid development of estimates that can be reassessed and refined once additional information is known. Since capability-based cost analysis is based on fairly simple concepts, it produces an intuitive end product that is attractive to decision makers (Hull, 2009).

One of the keys to the effective use of capability-based cost analysis is that it requires the generation of variables specific enough to meaningfully differentiate among systems and capability sets, but broad enough to be used with the limited information available at Milestone A. One of the first tasks undertaken by the team was to devote significant research and data collection time to searching for a standardized, broad set of capabilities. This capability set had to be unambiguous in language, extremely precise in description, and valid for use as a classifier or variable. Although the immediate intuition led us to the Joint Capability Areas (JCA) or Joint Integrated Activity Sets (JIAS), our efforts to conform these architectures to our particular requirements yielded little.

However, the System Capabilities Architecture (SCA), the capability variable set developed and used by ODASA-CE, leverages much from the JCA, and in fact maps directly to it with our capability-based cost analysis tool—the Capabilities Knowledge Base (CKB) (Sibert, 2009). In addition, the SCA is a fluid entity that continues to evolve based on improvement of available information and subject matter expert/peer review. As new systems are added to the CKB and knowledge of the acquired capability inventory grows, the SCA has and will continue to change.

The SCA uses plainly worded, high-level capabilities like "Move," "Shoot," "Communicate," "Sense Environment," and "Sustain" (for example), and then drills down into them. It enables the analyst to ask questions such as, Does my pre-Milestone A solution *Move*? and be able to identify an unambiguous *yes* or *no* answer. The initial framework has developed, refined, and augmented into what we believe is a suitable structure for capabilities-based parametric data analysis. This architecture is directly linked to the JCA so that department capability gaps can directly translate to capability-based analysis. However, this is certainly a living document that changes as we learn more about the department's currently acquired and future capabilities.

When developing capability maps for systems residing within the CKB or for systems being analyzed, it is imperative to involve knowledgeable platform subject matter experts to the fullest extent possible. Although situations where analysis time is limited (and therefore collaboration time is limited) certainly arise, such situations are suboptimal. Defining a thoroughly documented system boundary is also important—in other words, clearly designate what is included and excluded from a system (or capability set). Detailed capability mapping procedures have been developed to accompany the SCA. These are necessary in order to standardize and expedite the mapping process, making it transparent and repeatable. Optimally, a CKB system user will easily be able to trace how a system was mapped to its capability set, or be able to spot any errors or anomalies quickly. Capability mapping is an iterative process subject to continuous improvement efforts by its community of interest (McCormack & Roper, 2009).

Conclusions

The department-wide efforts during recent years to enable early investment decision making have demonstrated the level of difficulty inherent in achieving such an objective. Clearly, a commitment to the fiscal responsibility and long-term acquisition stability that pre-Milestone A decision making can provide will require far-reaching culture change and a willingness to look beyond the typical issue set. Pre-Milestone A analysis is the foundation upon which investment decision making is built; understandably, a knowledge and appreciation for some of the most challenging obstacles to building this foundation is imperative. The required level of analysis and cost estimate detail must be clearly specified so that ambiguity is kept to a minimum. Additionally, the body of analysts within the department must reach a common understanding of how to define and frame capability information in order to enable capability-based analysis that is universally understood. Change is not easy, and inertia is difficult to counter; but, for early investment decisions to be successful,

the forces of friction that prevent effective pre-Milestone A analysis must be overcome.

Author Biography

Ms. Martha "Marti" A. Roper is a senior operations research analyst for the Office of the Deputy Assistant Secretary of the Army for Cost and Economics (ODASA-CE). Currently, she leads pre-Milestone A life cycle cost initiatives, and previously conducted investigations into foreign military technologies development at the National Ground Intelligence Center. Ms. Roper holds a BA and an MS in Industrial and Systems Engineering (ISyE) from the Georgia Institute of Technology.

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