



Methods and Challenges in Early Cost Estimating

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Agenda

- Objective
- Early Cost Estimating Background
- Early Cost Estimates: Where to Start
- Developing a Cost Estimate in a High-Uncertainty Environment
 - Dismounted Observer Targeting Scenario
 - Light Tactical Mobility Scenario
- Early Cost Estimating Challenges
- Summary

Objective



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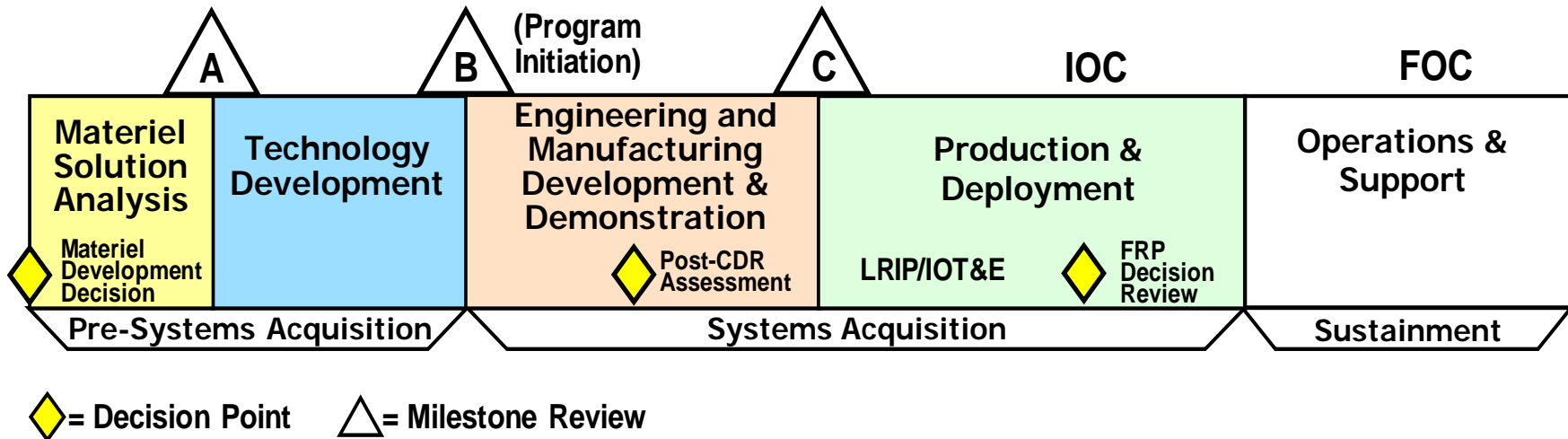
- The objective of this briefing is to:
 - Present some ideas that can be used to produce an Early Cost Estimate,
 - Show how Capability-Based Cost Estimating can be used to enable Early Costing efforts, and
 - Discuss some challenges with Early Cost Estimating

Early Cost Estimating Background



Early Cost Estimating

What Is It and Why Is It Important?



- 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
 - In the past, most Army programs first surfaced for a decision at Milestone B
 - DoD leadership recently began requiring a Milestone A decision for Army programs
- New DoDI 5000.02 requires cost estimates for Milestone A decisions and for Milestone A Analyses of Alternatives (AoAs)

Early Cost Estimating is defined as Pre-Milestone A Cost Estimating and is needed to better inform early investment decisions



Pre-Milestone A Cost Estimating

How Is It Different?

- There are fewer documents available for analysis during the Pre-Milestone A timeframe
- There is less detailed information available during the Pre-Milestone A timeframe
 - Post-Milestone A documents provide detailed technical and programmatic insight into the system we have to cost (i.e. weight of the system, maximum effective range of the system, production quantity, etc.)
 - Pre-Milestone A documents will most likely not have any technical or programmatic information and may only provide a capability (i.e. light tactical mobility capability, target identification capability, etc.)

Pre-Milestone A Cost Estimating

Available Documents

- Initial Capabilities Document (ICD)
- Functional Needs Analysis (FNA)
- Functional Solutions Analysis (FSA)

Post-Milestone A Cost Estimating

Available Documents

- All Pre-Milestone A Documents
- Capabilities Development Document (CDD) and/or Capabilities Production Document (CPD)
- Cost Analysis Requirements Document (CARD)

How can we estimate the cost for something if we only know its capabilities and nothing else?



Capability-Based Cost Estimating

Using Capability-Based Information to Produce a Cost Estimate

Capability-Based Cost Estimating

- ❖ *We Can Use the Capabilities of Current Systems and Their Associated Costs to Provide Cost Estimates For Capability-Gap-Filling Solutions*



Pre-Milestone A Cost Estimating

- ❖ *Analysis That Uses Information Known Prior to Milestone A to Create a Cost Estimate*
 - ❖ *Theoretical Worst Case Scenario: Capabilities Only*
 - ❖ *If We Know More, We Can Improve Fidelity*
 - ❖ *A Risk-Informed Estimate That Provides a Likely Cost Range*

Capability-Based Cost Estimating is a tool that can enable Pre-Milestone A Cost Estimating



Early Cost Estimating Concerns

- It is very difficult to produce a cost estimate when we do not have any programmatic information available such as:
 - Prototype quantities
 - Production quantities
 - Production schedules
 - Fielding schedules
 - Operation and Support (O&S) plans
- It is very difficult to produce a cost estimate when we do not know exactly what it is that we have to cost
 - We will most likely not have a good description of the system
 - We will most likely not know any technical or performance characteristics of the system
 - We may only know what capabilities the system is supposed to have

How can we even begin an Early Cost Estimate with so little information available for analysis?

Early Cost Estimates: Where to Start



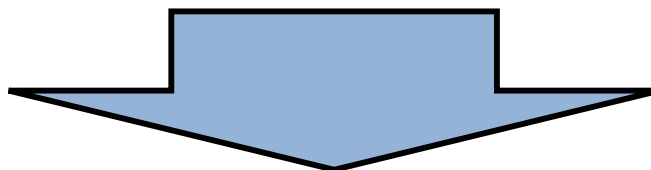
Starting An Early Cost Estimate

Think of the End State First

- When basic programmatic information such as quantities is missing, it is impossible to produce a traditional Life Cycle Cost Estimate (LCCE)
- A way around this issue is to think of a way to display cost results that does not depend on quantities

Traditional Display of Cost Results

RDTE	Total RDTE Cost
Procurement	Total Procurement Cost
O&S	Total O&S Cost



Potential Display of Pre-Milestone A Cost Results

RDTE	Development Engineering Cost Recurring RDTE Cost Per Prototype
Procurement	Average Procurement Unit Cost for First Unit
O&S	O&S Cost Per System Per Year



Displaying Cost Results

Finding the Appropriate Level of Detail

- With less information at during the Pre-Milestone A timeframe, it can be expected that there will be less detail in cost result displays
- Traditionally, we tend to display costs in a detailed Work Breakdown or Cost Element Structure; the Pre-Milestone A world most likely will not let us display costs down to this level

Traditional Level of Detail for RDTE Cost Results

1.0. Total RDTE Cost
1.01. Development Engineering Cost
1.04. Prototype Manufacturing
1.05. System Engineering / Program Management
1.06. System Test and Evaluation
1.07. Training
1.08. Data
1.11. Other RDTE



Potential Level of Detail for Pre-Milestone A RDTE Cost Results

Development Engineering Cost
Recurring RDTE Cost Per Prototype



Developing a Cost Estimate in a High-Uncertainty Environment



Methodologies

Using Capability-Based Cost Estimating

- Capability-Based Cost Estimating is an important tool that can be used to produce a Pre-Milestone A Cost Estimate for a system when there is little to no performance or technical information available on that system
- In the Pre-Milestone A world, atypical methodologies may have to be utilized to extract limited available information from capability-based documents in order to produce an estimate
- Our Early Cost Team has developed methodologies to support two different Early Costing scenarios
 - Dismounted Observer Targeting Scenario
 - Light Tactical Mobility Scenario



Dismounted Observer Targeting Scenario

Methodologies

Dismounted Observer Targeting Scenario

- A Targeting System AoA was being conducted to determine if DoD should improve existing Targeting Systems or develop a new system
- Targeting System ICD described capability gaps in target location and target designation that identified during Global War on Terror operations
 - ICD provided required performance parameters (target identification range, target location error, etc.) as well as required capabilities
 - ICD provided current targeting systems that we used as analogies
- None of the systems in our analogous dataset met the ICD requirements
 - Some systems only had part of the required ICD capability
 - No systems achieved the required ICD performance

Required ICD Capability

- Laser Rangefinder Capability
- Laser Designation Capability
- Infrared Marking Capability
- Higher Performance than Current Capabilities Achieve
 - Farther Night Identification Range
 - Farther Day Identification Range
 - Better Target Location Error

Analogous Systems



Mark VII E had a Laser Rangefinder capability but no Laser Designation capability



Ground Laser Target Designator II (GLTD II) had a Laser Designation capability but no Laser Rangefinder capability



Lightweight Laser Designator Rangefinder (LLDR) had a Laser Rangefinder and Laser Designation capability but Infrared Marking capability



Methodologies

Dismounted Observer Targeting Scenario (continued)

- Current analogous systems had to be combined to achieve system combinations that could achieve the ICD required capabilities
- Analysis showed that certain performance parameters tended to be cost drivers
 - Night Target Identification Range (meters)
 - Day Target Identification Range (meters)
 - Target Location Error (miliradians)
- Analysis also showed that certain capabilities tended to be cost drivers
 - Target Designation Capability (i.e. whether or not a system could designate a target)
 - Infrared Marking Capability (i.e. whether or not a system could mark a target)
- Resulting Cost Estimating Relationship used both performance and capability-based variables
 - Performance variables used range and miliradian values
 - Capability variables used binary values (1 if the system had the capability and 0 if the system did not)
- This scenario was seen as a best-case Early Costing scenario due to how much detailed information the ICD provided

Light Tactical Mobility Scenario



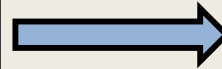
Methodologies

Light Tactical Mobility Scenario

- A Light Tactical Mobility Evaluation of Alternatives (EoA) was being conducted to determine whether DoD should upgrade current Light Tactical Vehicles, buy Commercial Off-the-Shelf Vehicles, or develop a new Light Tactical Vehicle
- We used Capability-Based Costing to verify and validate the cost estimate for the new Light Tactical Vehicle Course of Action (COA)
- The Joint Light Tactical Mobility (JLTM) ICD specified that the solution would be a vehicle but provided no performance or technical specifications
- When only capabilities are provided in the ICD with no performance or technical specifications, one possible way forward is to link provided capabilities to performance or technical parameters

Examples of Capabilities that Link to Performance and/or Technical Parameters

Capability: Mobility



Performance Parameter: Speed (mph)

Capability: Shoot



Performance Parameter: Maximum Effective Firing Range (km)

Capability: Transportable



Technical Parameter: Curb Weight (lbs)



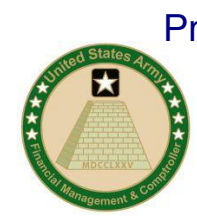
Methodologies

Light Tactical Mobility Scenario (continued)

- We were able to use capability to performance parameter mapping to estimate a cost for the new Light Tactical Vehicle COA
 - Curb Weight is often a cost driver for vehicles
 - The ICD did not specify a Curb Weight for the vehicle, but indicated that the system had to be externally transportable by a CH-47 Helicopter
 - This provided a Curb Weight upper bound that we could use to aid in building a cost estimate
- Our cost result for the new Light Tactical Vehicle COA came within 10% of the RDTE and Procurement estimates in the EoA Cost Estimate
- This scenario was seen as a more typical Early Costing scenario; the ICD was detailed enough to indicate that a vehicle was the solution but only provided capabilities for analysis



Early Cost Estimating Challenges





Early Cost Estimating Challenges

Capability-Based Planning Scenarios

- One challenge we may run into is when we are asked to provide a cost estimate for a Capability-Based Planning Scenario when we are only provided information on capabilities
- A very simple example would be if we were asked to provide a cost estimate for the capability to cross from one side of a river to another
- One way to move forward is to:
 - Assume various materiel solutions that could get across the river (aircraft flying over the river, watercraft traversing the river, or vehicle crossing a bridge over the river)
 - Make assumptions and develop estimates for each mode of transportation (these would be very rough estimates and it might be appropriate to use ranges of costs)
 - This methodology could even take into account costs for the non-materiel solution of simply swimming across the river

Requirement: Cost of the Capability to Cross the River



Costs of Various Solutions

A-B \$K for a
Watercraft Solution



C-D \$K for an
Aircraft Solution



E-F \$K for a
Vehicle Solution



Early Cost Estimating Challenges

Capability-Only Scenarios

- In cases where analysts are only given a capability set to work with, one way to develop an estimate is to use what is known as a “cost per capability” tool
- The Cost Per Capability Tool we are developing solves systems of linear equations in an Excel Solver framework
- This methodology produces a very rough cost estimate and is envisioned for analysis of early “quick-turn” decision making scenarios

Simple Cost Per Capability Example:

Problem: We want to estimate the cost for a new system with Capabilities X, Y, and Z

Issue: Based on capabilities alone, we have 3 semi-analogous systems but nothing with all three desired capabilities

Solve for Cost of Capabilities X, Y, and Z using Cost Per Capability Analysis:

$$\text{Capability X Cost} + \text{Capability Y Cost} = \text{Actual System 1 Cost}$$

$$\text{Capability Y Cost} + \text{Capability Z Cost} = \text{Actual System 2 Cost}$$

$$\text{Capability X Cost} + \text{Capability Z Cost} = \text{Actual System 3 Cost}$$

while minimizing the Sum of Squared Errors between Estimated and Actual Costs of the 3 systems

$$\begin{aligned} & (\text{Estimated System 1 Cost} - \text{Actual System 1 Cost})^2 \\ + & (\text{Estimated System 2 Cost} - \text{Actual System 2 Cost})^2 \\ + & (\text{Estimated System 3 Cost} - \text{Actual System 3 Cost})^2 \end{aligned}$$

Minimize: Sum of Sum of Squared Errors

Result: Capability X Cost + Capability Y Cost + Capability Z Cost = Cost of New System

Early Cost Estimating Challenges

Software Cost Estimating

- Software Cost Estimating is a challenge in the Post-Milestone A timeframe, and Pre-Milestone A Software Cost Estimating is no different
- Intuitively, a software solution should cost more if it has more capability
- Lack of software development data is an issue
- We were able to take a capabilities-based approach to estimate the cost for a new Targeting Effects Coordination System
 - We were able to look at how many different types of platforms the system was required to talk to (aircraft, tactical operation centers, etc.)
 - We were able to look at the message formats that were required for the system to talk to other systems (VMF, Link 16, etc.)
 - Using Subject Matter Expert-provided Lines of Code and adjustments for code growth for analogous Indirect Fire Coordination systems, we were able to estimate a rough range of costs for the new Targeting Effects Coordination System
- We are continuously looking for better ways to use Capability-Based Cost Estimating to produce Pre-Milestone A Software Cost Estimates





Summary



Summary

- Pre-Milestone A and Capability-Based Cost Estimating are by no means simple processes
- Developing these estimates is necessary due to leadership demand for cost information much earlier in a system's acquisition lifecycle
 - Leadership is going to make early decisions with or without input from cost analysts
 - 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 we inform decision-makers of the risk and uncertainty involved in Early Cost Estimating and that the cost estimates will evolve as more information becomes available, we have done our job