Department of the Navy Independent Cost Assessment Manual

Naval Center for Cost Analysis

This Manual defines processes and procedures for performing an independent cost assessment (ICA) of the life-cycle cost estimate of an ACAT ID acquisition program in the Department of the Navy.

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FOREWORD

Life-cycle cost estimates of defense acquisition programs are inherently uncertain. Estimates are sometimes required when little if any of a program's total cost is known. Years of system development and production, and decades of operating and support costs, need to be estimated. Estimates, in turn, are based on historical samples of data that are often difficult and costly to obtain. Significant efforts are commonly required to squeeze usable information from a limited, inconsistent sample. And no matter what estimating tool or method is used, historical observations never perfectly fit a smooth line or surface, but instead fall above and below an estimated value.

To complicate matters, the weapon system or automated information system under study is often of sketchy design. Only limited programmatic information may be available on such key parameters as schedule, production quantities, performance, acquisition strategy, and future incremental capability requirements. Further, key characteristics of the system may actually change as the system proceeds through development and even production. Increases in system weight, complexity, and lines of code are commonplace.

Given the size and complexity of modern weapon systems, the inherent difficulty of the cost estimating job, and the record of acquisition cost growth in the Department of Defense, the Independent Cost Assessment (ICA) is value-added to our decision making.

This Manual defines processes and procedures for performing assessments of the completeness, accuracy, and credibility of life-cycle cost estimates of major defense weapon system acquisition programs and business systems in the Department of the Navy. I promulgate the Manual in the spirit of providing our senior leadership with *independent, analytical insight* that is critical, in our fiscally-challenged environment, to deliver needed capability downrange to our warfighters.

Wendy P. Kunc

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PREFACE

Cost growth on major defense weapon-system acquisition programs has been a vexing, long-standing, and seemingly intractable problem in the Department of Defense. According to the Chairman of the Senate Armed Services Committee, "Since the beginning of 2006, nearly half of DoD's Major Defense Acquisition Programs (MDAPs) have experienced critical [Nunn-McCurdy] cost growth." [1] DON acquisitions of ships, aircraft, and missiles contribute to the mix. Egregious examples of troublesome Navy programs include 200% cost growth on a lead-ship design and construction contract and cost and technical issues on an aircraft development effort that led to its cancelation.

To shed statistical light on the dual issues of cost growth and cost risk, the Naval Center for Cost Analysis (NCCA) culled data from Selected Acquisition Reports and tallied cost growth indices on a large sample of DON acquisitions over the past three decades: [2]

$$Cost\ Growth\ Factor = \frac{Actual\ Acquisition\ Cost}{Estimated\ Acquisition\ Cost}$$

As Table 1 shows, *average* cost growth for an historical DON MDAP at Milestone B is 23%, even *after* eliminating the effects of changes in inflation and acquisition quantities. On a cost-per-unit or Nunn-McCurdy computational basis, DON programs fall midway between the 30% *significant* and the 50% *critical* breach thresholds, on average.[3]

	Without Quantity Adjustment		Quantity Adjusted	
Statistics	Base-Year$	Then-Year$	Base-Year$	Then-Year$
Mean	1.48	1.84	1.23	1.36
Standard Deviation	0.94	1.60	0.44	0.69
Coefficient of Variation	0.63	0.87	0.36	0.51

Table 1: Cost Growth Factors and CVs for DON MDAPs at MS B

[1] Senator Carl Levin, February 24, 2009, introducing the Weapon System Acquisition Reform Act.

[2] "Development and Application of CV Benchmarks," DODCAS 2011, Mr. Peter Braxton, Dr. Brian Flynn, Dr. Paul Garvey, Mr. Richard Lee.

[3] For DON MDAPs, the average delta (actual versus estimated) in the Nunn-McCurdy "Program Acquisition Unit Cost" metric is 40%, measured in constant dollars from the original baseline. Calculations, not shown here, are available from NCCA.

Focusing on calculations in then-year dollars but adjusting for changes in acquisition quantity, which are generally regarded as outside the purview of the cost analyst, Figure 1 shows a skewed distribution of cost outcomes. Some programs come in under estimated cost but most fall to the right of the on-target index of 1.0 where actual cost equals estimated cost. One program exhibits close to 300% cost growth. Average cost growth is 36%, measured from the program baseline.

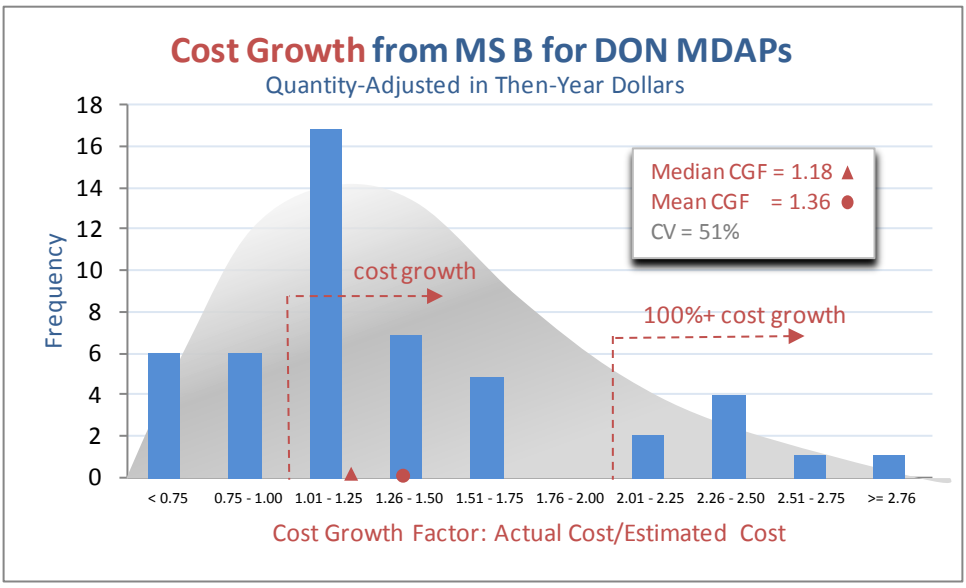

Figure 1

NCCA also finds, through statistical tests of hypotheses of platform *CV* homogeneity, that *risk of cost growth* impacts equally aircraft, ship, missile, electronics, and other types of acquisitions across the Systems Commands. The findings are consistent with results from enumerable studies, independent reviews, and Congressional investigations.[4]

This backdrop of stubbornly persistent cost growth, coupled with the inherent challenges in life-cycle cost estimating, *underscores* the need for *independent cost assessments* of the DON's most important, technically demanding, and highest dollar-value programs. As the Secretary of the Navy's instruction on cost analysis emphasizes, improving "visibility and understanding of major program costs" is *imperative*, along with an "independent evaluation of risk and uncertainty."[5]

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[4] NCCA's estimated CV of 51% at Milestone B for DON programs [Table 1; quantity-adjusted in then-year dollars] accords perfectly with a recent, identical computation based on a sample of over 300 MDAPs across the Services. The other military departments, then, experience the same magnitude of cost growth and cost risk as the DON.

[5] SECNAVINST 5223.2A, "Department of the Navy Cost Analysis," page 2; Mr. Robert O. Work, Under Secretary of the Navy, 3 Dec 2013.

ABBREVIATIONS

ACAT	Acquisition Category
AIS	Automated Information System
AoA	Analysis of Alternatives
APUC	Average Procurement Unit Cost
ASN(FM&C)	Assistant Secretary of the Navy (Financial Management and Comptroller)
ASN(RDA)	Assistant Secretary of the Navy (Research, Development and Acquisition)
BA	Budget Authority
Big "A"	JCIDS, DAS, and PPBES decision-support systems in DoD
BY$	Base Year dollars
CAPE	OSD Cost Assessment and Program Evaluation
CBA	Capability-Based Assessment
CCDR	Contractor Cost Data Report
CDD	Capabilities Development Document
CDR	Critical Design Review
CER	Cost Estimating Relationship
CES	Cost Element Structure
CGF	Cost Growth Factor
CJCS	Chairman of the Joint Chiefs of Staff
CONOPS	Concept of Operations
COTS	Commercial Off-the-Shelf
CPD	Capabilities Production Document
CPR	Contract Performance Report
CRB	Cost Review Board
CSDR	Cost Schedule Data Report
CUMAVG	Cumulative average
CV	Coefficient of Variation
DAB	Defense Acquisition Board
DAES	Defense Acquisition Executive Summary (Report)
DAG	Defense Acquisition Guidebook
DAS	Defense Acquisition System
DASN(C&E)	Deputy Assistant Secretary of the Navy (Cost and Economics)
DoD	Department of Defense
DoDAF	Department of Defense Architecture Framework
DoDCAS	Department of Defense Cost Analysis Symposium
DON	Department of Navy
DT&E	Development Test and Evaluation
EA	Economic Analysis
EAC	Estimate At Completion
EMD	Engineering and Manufacturing Development
eSBM	enhanced Scenario Based Method
ESLOC	Equivalent Source Lines of Code
EVM	Earned Value Management
FOC	Full Operational Capability
FP	Function Point
FPRA	Forward Pricing Rate Agreement
FPRP	Forward Pricing Rate Proposal
FPRR	Forward Pricing Rate Recommendation
FY	Fiscal Year
FYDP	Future Years Defense Program
G&A	General and Administrative
GAO	Government Accountability Office
GR&A	Ground Rules and Assumptions
ICA	Independent Cost Assessment
ICD	Initial Capabilities Document
ICE	Independent Cost Estimate
IE	Industrial Engineering
iid	Independently and identically distributed
ILS	Integrated Logistics Support
IOC	Initial Operational Capability
IV&V	Independent Verification and Validation
JCIDS	Joint Capability Integration and Development System
JCS	Joint Chiefs of Staff
JROC	Joint Requirements Oversight Council
KPP	Key Performance Parameter
KSA	Key System Attribute
M	Materiel solution in the DOTmLPF-P spectrum of military capability

MAIS	Major Automated Information System
MAR	MAIS Annual Report
MCS	Monte Carlo Simulation
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MER	Manpower Estimate Report
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MQR	MAIS Quarterly Report
MS	Milestone (A, B, or C)
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Aviation Systems Command
NAVSEA	Naval Sea Systems Command
NCCA	Naval Center for Cost Analysis
NDAA	National Defense Authorization Act
O&M	Operations and Maintenance
O&S	Operating and Support
OH	Overhead
OLS	Ordinary Least Squares
OPNAV	Operational Navy
OPTEMPO	Operational Tempo
ORR	Operational Readiness Review
OSD	Office of the Secretary of Defense
PARCA	Office of Program Assessment and Root Cause Analysis (OSD)
PAUC	Program Acquisition Unit Cost
PBS	Process [work] Breakdown Structure (ICA)
PDF	Probability Density Function
PDR	Preliminary Design Review
PLCCE	Program Life-Cycle Cost Estimate
PM	Program Manager
PPBES	Planning, Programming, Budgeting, and Execution System
PRR	Production Readiness Review
PSE	Peculiar Support Equipment
QA	Quality Assurance
R&D	Research and Development
R2	Coefficient of Determination
RDT&E	Research, Development, Test, and Evaluation
RICE-FW	Reports, Interfaces, Conversions, Enhancements, Forms, and Workflows [objects]
S-Curve	Graph of cumulative probability distribution
SAR	Selected Acquisition Report
SCP	Service Cost Position
SDR	System Definition Review
SECDEF	Secretary of Defense
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy Instruction
SEE	Standard Error of the Estimate
SEP	Systems Engineering Plan
SLOC	Software Lines of Code
SME	Subject Matter Expert
SPAWAR	Space and Warfare Systems Command
Spruill Chart	Estimated program funding requirement by appropriation by year
SRDR	Software Resource Data Report
SWAP	Space, Weight, and Power
SWBS	Ship Work Breakdown Structure
SYSCOM	Systems Command
T&E	Test and Evaluation
T1	Value of first unit on a learning curve
TD	Technology Development
TEMP	Test and Evaluation Master Plan
TOA	Total Obligational Authority
TOC	Total Ownership Cost
TRB	Technical Review Board of NCCA
TRL	Technology Readiness Level
TRR	Test Readiness Review
TY$	Then Year dollars
USC	United States Code
USD(AT&L)	Undersecretary of Defense (Acquisition, Technology and Logistics)
USMC	United States Marine Corps
WBS	Work Breakdown Structure
WSARA	Weapon System Acquisition Reform Act of 2009

INTRODUCTION

DEFINITION

An Independent Cost Assessment (ICA) is a non-advocate, outside-the-chain-of-command evaluation of a program life-cycle cost estimate that examines its completeness, accuracy, credibility, and documentation.

MANDATE

In accordance with SECNAV Instruction 5223.2A, the Naval Center for Cost Analysis (NCCA) executes an ICA for all DON ACAT I programs and selected ACAT IIs by:

- Reviewing "cost [estimation] processes and key assumptions to ensure cost estimates are consistent with DON policy and … guidance frameworks;"[6]
- Providing "increased visibility and understanding of major program costs and cost growth," and
- Independently evaluating cost "risk and uncertainty."

FOCUS

The ICA focuses laser-beam attention on cost risk and uncertainty analysis and also reviews each of the steps employed in generating a detailed and comprehensive life-cycle cost estimate, defined as:

> <u>Cost Estimate</u>
> A complex set of relationships between assumptions, baseline programmatic and technical parameters, cost and financial factors, statistical equations, and estimating objectives, all known with less than perfect certitude, and built judiciously to create time-phased projections of life-cycle costs several decades ahead, by appropriation and in base-year and then-year dollars, with the probability and consequence of uncertain and risky events duly underscored.

Unlike an Independent Cost Estimate (ICE) or a Program Life-Cycle Cost Estimate (PLCCE), the ICA does not build-up a cost estimate from the baseline, and is not a stand-alone product. Rather, the ICA reviews and interprets data collection and analyses underway as the PLCCE is built step by step. The amount of work required for the ICA depends upon

[6] These frameworks include the *DON Cost Estimating Guide*, "A Compendium of Best Practices for the Department of the Navy Cost Analysis Community," Ms. Kunc, DASN (Cost and Economics), 2010.

the degree to which the cost estimate reflects use of best practices, and the technical and programmatic risk of the acquisition program under review.

With an emphasis on *independent* assessment, the ICA often uses "… the same procedures as those of the program estimate but [with] … different methods and techniques [employed]."[7] Table 2 notes some of the features distinguishing a cost estimate and an ICA.

Step	Life-Cycle Cost Estimate	Independent Cost Assessment
Establish ICA Plan	No action	NCCA action
Understand Program Baseline	Compile and analyze information from all relevant documents and reviews. Verify with SYSCOM stakeholders.	Assess baseline accuracy and completeness. Assess validity of program postulates. Ensure coverage of risk parameters.
Collect & Normalize Data	Execute end-to-end effort. Conduct exploratory data analysis.	Assess completeness and accuracy of effort. Collect additional information as required for ICA cross checks.
Build the Point Estimate	Generate a baseline cost estimate for every WBS element; use cross checks if possible; verify results; design and build cost model.	Validate cost model. Assess accuracy & statistical validity of engineering, parametric, & analogy estimates. Generate ICA estimates only for cost drivers, as needed.
Conduct Risk Analysis	Execute a complete, bottoms-up estimate of risk and uncertainty.	Assess quality of risk analysis and execute independently.
Communicate Results	Present a complete, time-phased cost estimate, adjusted for risk and uncertainty.	Assess documentation quality. Present issues, alternative estimates of select WBS elements, and results of independent risk analysis.
Intent of Product	Execute a bottoms-up estimate of risk and uncertainty.	Assess quality of risk analysis and execute independently.
Interaction Between Cost Agencies	Reconciliation of separate estimates in the case of Independent Cost Estimates.	On-going crosstalk via peer reviews, with no formal reconciliation.

Table 2: Sample of Distinguishing Features of an ICA and a Cost Estimate

[7] *GAO Cost Estimating and Assessment Guide*, March 2009, Table 27, "Eight Types of Independent Cost Estimate Reviews," page 188.

SCOPE

Per SECNAV direction, independent assessments of PLCCE's apply to all DON ACAT I programs, in support of milestone reviews, and for ACAT II programs as directed by the Assistant Secretary of the Navy (Financial Management and Comptroller), ASN(FM&C).[8]

This ICA Manual, to support this direction, serves as the guideline for producing a complete, thorough, documented assessment of a program office cost estimate. The independent assessment, in turn, is critical input at a Cost Review Board (CRB), along with the PLCCE, in establishing a DON Service Cost Position (SCP) for major DON acquisitions.

The ICA attempts to independently ensure that the PLCCE meets stakeholder requirements[9] and is of "high quality;" that is, "complete, accurate, credible, and well-documented:"[10]

- **Completeness**
  Ensures that the estimate covers all cost elements in the program baseline while double counting none, and, that the estimate covers all elements in any excursions to the baseline.

- **Accuracy**
  Ensures that the cost model is mathematically sound, or error free, and that the cost estimate is neither biased upward nor downward, in terms of both the point estimate and its associated probability distribution.

- **Credibility**
  Ensures that the estimate meets stakeholder requirements; maximizes the use of scientifically-sound principles while minimizing subjectivity; tests and revisits assumptions; and assesses risk and uncertainty.

- **Documentation**
  Ensures that the estimate is completely documented, including data sources, methodology, and ground rules and assumptions.

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[8] SECNAV Instruction 5223.2A, page 2.

[9] Stakeholders are ASN(RDA), ASN(FM&C), OSD CAPE, USD(AT&L), and all members of the DON Cost Review Board. Requirements may vary by milestone and by program. They might include examination of unique elements of Total Ownership Cost (TOC), cost-capability tradeoffs at MS A, and costs of alternative sustainment plans.

[10] *GAO Cost Estimating and Assessment Guide*, page 180.

Execution of the ICA, by design, involves a review of the steps employed in creating the cost estimate. Areas of focus include an evaluation of the soundness and solidity of requirements, key assumptions, and technical baselines; the provenance and pedigree of analogies and historical data; and the conformance of the estimate to best practices in DON cost analysis.[11] The ICA also requires a thorough and complete hands-on understanding and review of the PLCCE cost model.[12]

The review, at times, may necessitate the application of different analogies or sets of historical data; the use of alternative tools and techniques; and independent assessments of degree of risk and uncertainty of a multitude of cost drivers.

The ICA, importantly, is executed by NCCA *independently* of influence from the acquisition community. As the Government Accountability Office notes,

> "…independent cost estimators are less likely to automatically accept unproven [baseline] assumptions." An "… independent view provides a reality check of the point estimate and helps reduce the odds that management will invest in an unrealistic program that is bound to fail." [13]

Finally, application of the ICA process defined herein can serve as value-added to improve quality of any life-cycle cost estimate prior to delivery to senior leadership.

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[11] *DON Cost Estimating Guide*.
[12] *GAO Cost Estimating and Assessment Guide*, page 180.
[13] Ibid., page 179.

APPLICABILITY

The ICA process is generic, all-inclusive, and intended to support the DON's requirement for an assessment throughout the acquisition and gate-review processes, as illustrated in Figure 2. The ICA supports Milestone A, B, and C decisions, Full-Rate Production Decision Reviews (FRP DRs), and program re-baselining. Unique cost-estimating and ICA requirements, such as support of cost/capability tradeoffs at MS A, are incorporated into the ICA Process [work] Breakdown Structure (PBS), where appropriate.

ICA Support of Acquisition Process

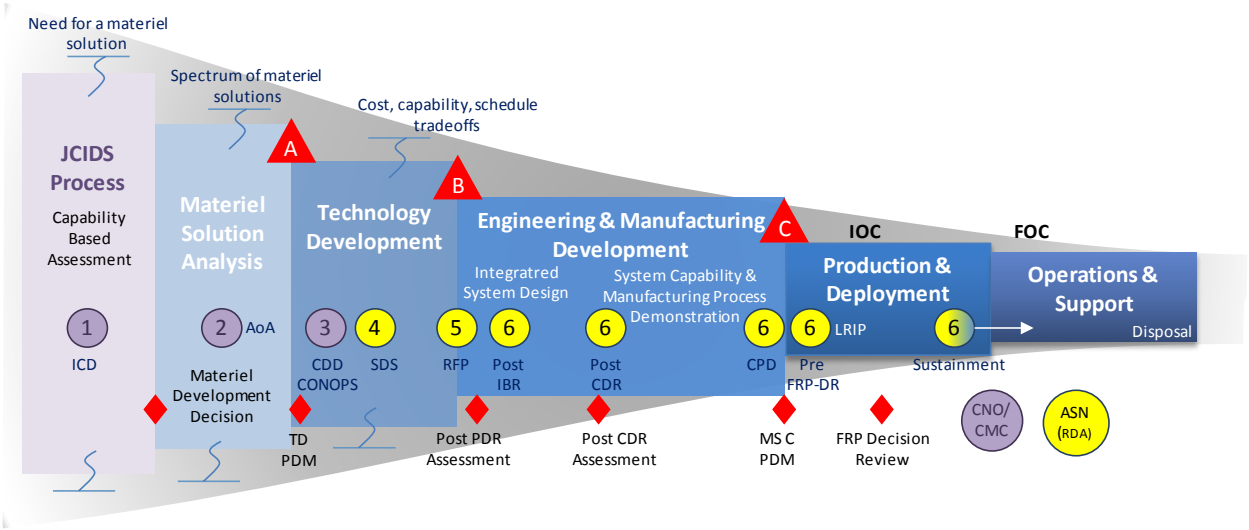

Figure 2

INTENT

Given the inherently difficult job of producing credible, cradle-to-grave cost estimates of complex weapon systems in a dynamic acquisition environment, the ICA strives to provide these benefits to DON leadership prior to advancing the program to review by the Office of the Secretary of Defense (OSD):

- Objective, independent appraisal of the life-cycle costs of the material solution under consideration;
- Increased understanding of the underlying postulates of the cost estimate, where sources of cost growth usually originate;
- Improved visibility into the strengths, weaknesses, and limitations of the cost estimate;
- Deeper understanding of major cost drivers and elements of cost risk; and
- Reduced errors in the cost estimate.

THE ICA PROCESS

FRAMEWORK

Development of a high-quality life-cycle cost estimate for a DON MDAP demands careful execution of each and every step in the cost-estimating process. Scope must be identified. The program baseline and associated work breakdown structure must be defined fully. Data must be collected and understood, and sound methodology developed. Risk and uncertainty analysis must be conducted. And results must be conveyed to senior leadership clearly and cogently.

Since the ICA is intended to inform and shape and PLCCE and the SCP from the "get-go," waiting until the delivery of the cost estimate to perform the assessment would yield minimum value-added. And it would introduce inefficiencies in the review process since cost estimators would be forced to revisit complicated, time-consuming steps executed months previously.

The steps of the ICA, therefore, are executed contemporaneously and in tandem with those used to produce the cost estimate under review, with the relationship between the two processes depicted in Figure 3.

ICA Framework and Relationship with the PLCCE Process

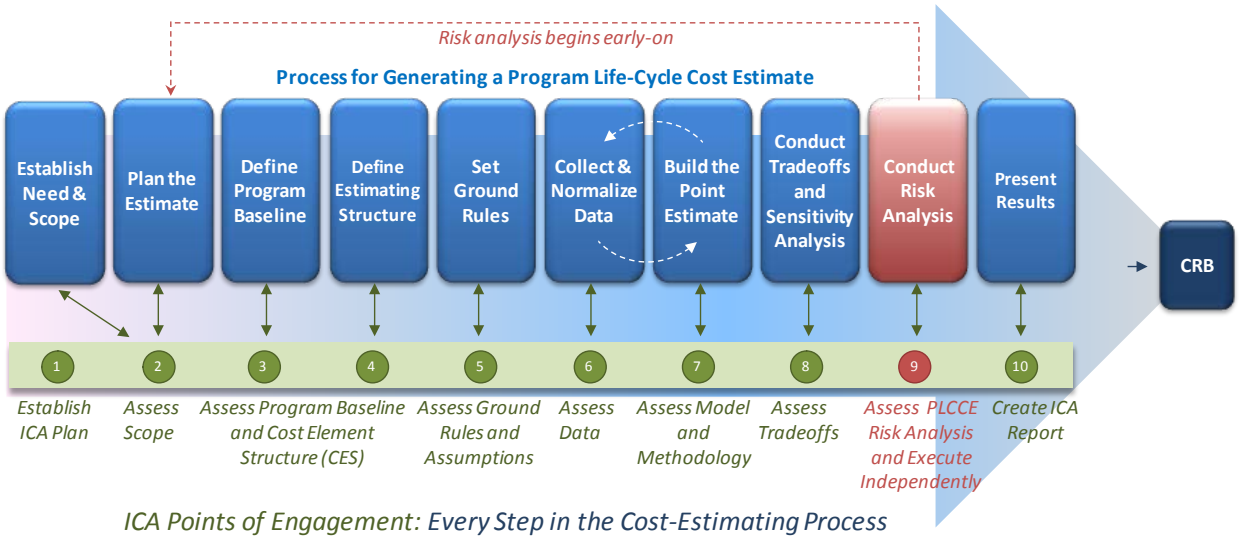

Figure 3

The first step in the ICA process, strictly speaking, is a planning rather than an assessment activity. Similarly, the last step, communicating results, involves both an assessment of PLCCE documentation as well as an independent report of ICA results.

The cost-estimating process often involves a repetition of steps. For example, methodology drives data collection, but limitations in the latter influence the former. Likewise, ICA steps are sometimes repetitive as new information is obtained.

LINKAGE

The design of DON's ICA process flows logically from the mandate of SECNAV Instruction 5223.2, with linkage between strategic requirements and ICA tasks, at the Tier 1 level, shown in Figure 4.

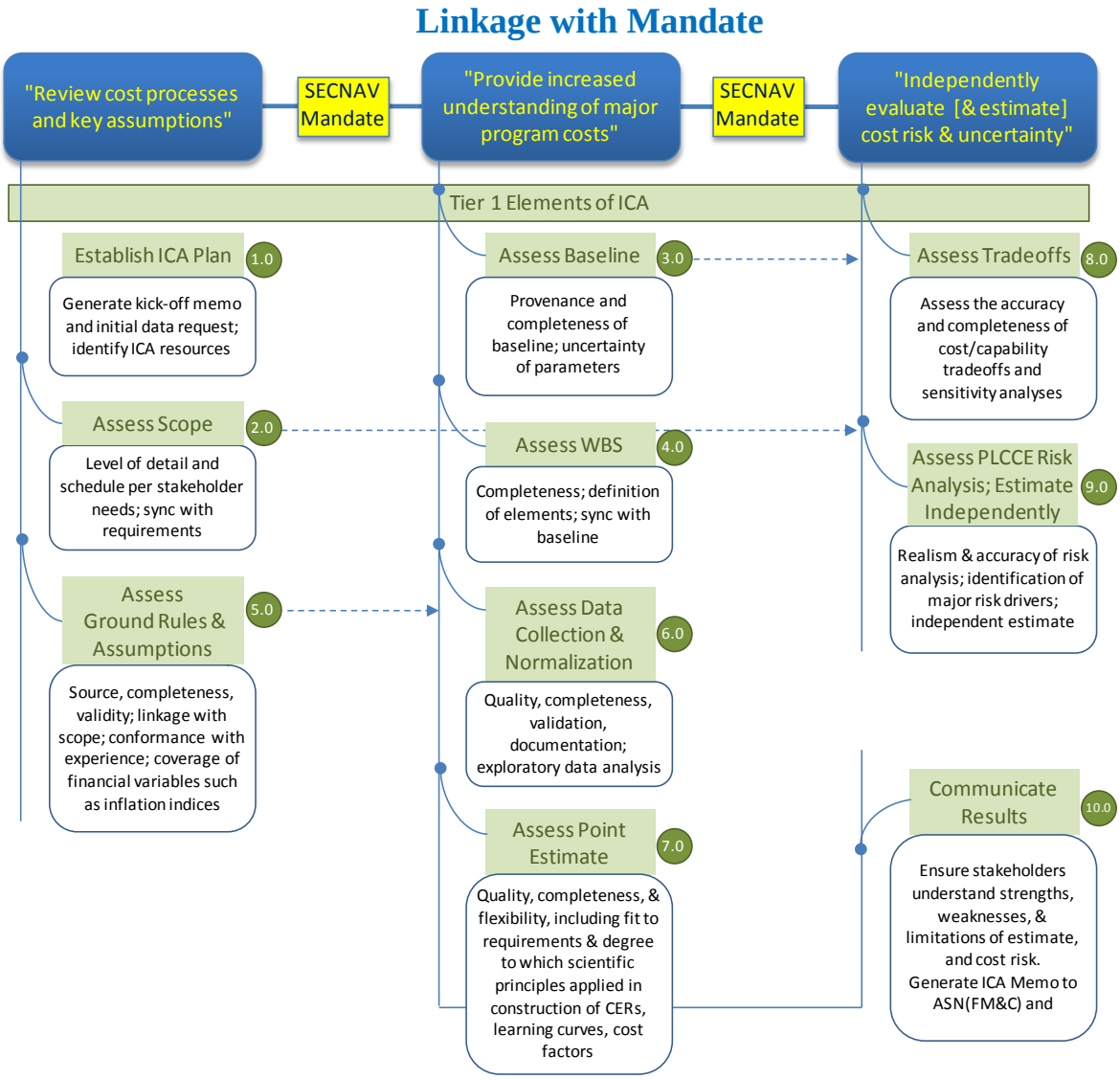

Figure 4

Each of these ten Tier 1 steps in the ICA entails execution of a hierarchy of sub-steps, much like a work breakdown structure, with a partial example shown in Figure 5 for the assessment of PLCCE methodology.

Example of ICA Process Breakdown Structure

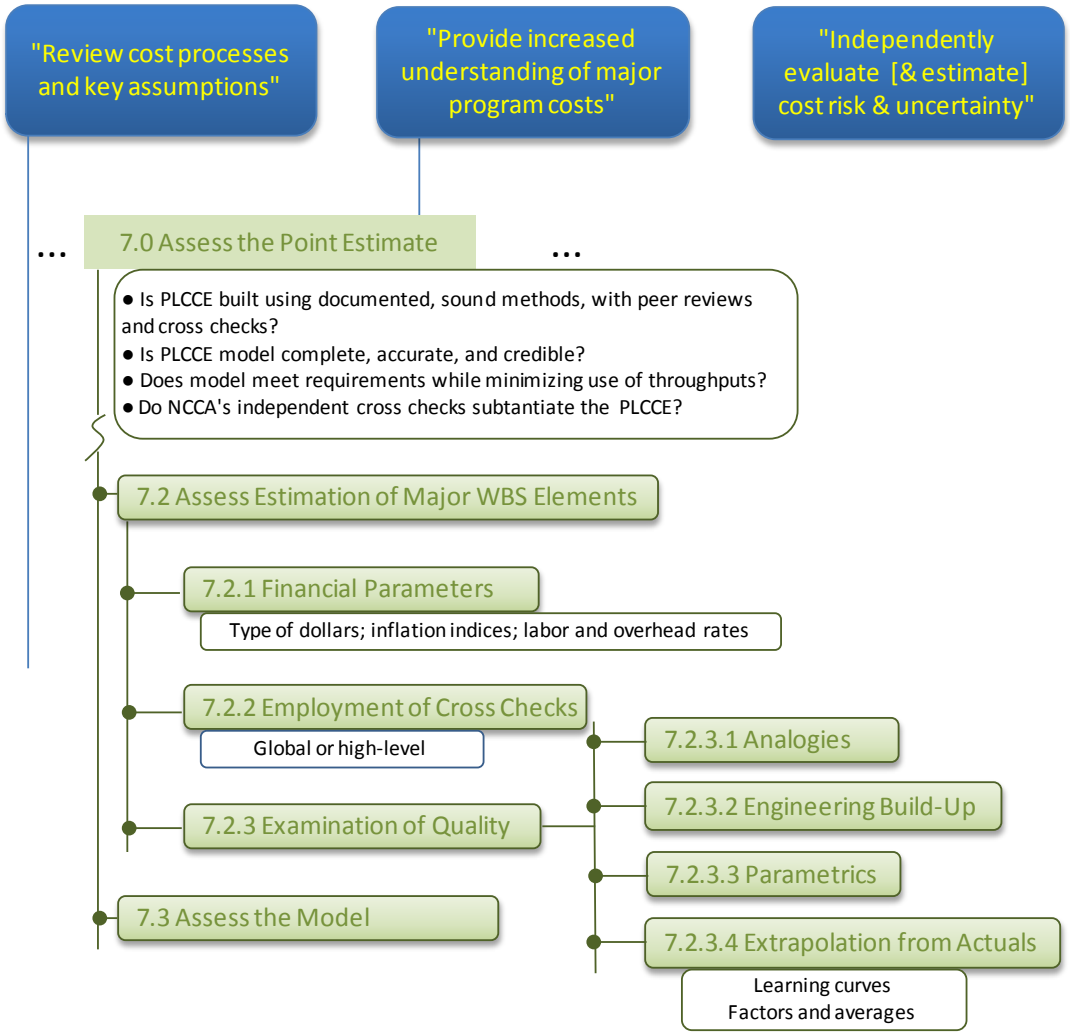

Figure 5

A top-level ICA PBS is presented at the end of this chapter, with complete details for each step presented in the remainder of the Manual.

EMPHASIS

The SECNAV mandate emphasizes "*independent*" execution of risk and uncertainty analysis as well as the related task of providing increased visibility and understanding of major cost drivers.[14]

The terms risk and uncertainty are related but not the same. The ICA distinguishes between the two as follows, with Figure 6 an example for a single WBS element:

- **Uncertainty**
  The indefiniteness or variability of an event. It captures the phenomenon of observations falling to the left or right of a mean or median value, or above and below a regression line. [*unexplained variance in software costs*]

- **Risk**
  Exposure to loss. Or, "a measure of future uncertainties in achieving program performance goals within defined cost and schedule constraints. It has three components: a future root cause, a likelihood assessed at the present time of that future root cause occurring, and the consequence of that future occurrence." [15] [*growth in modal value of SLOC count*]

Example of Risk and Uncertainty for a WBS Element

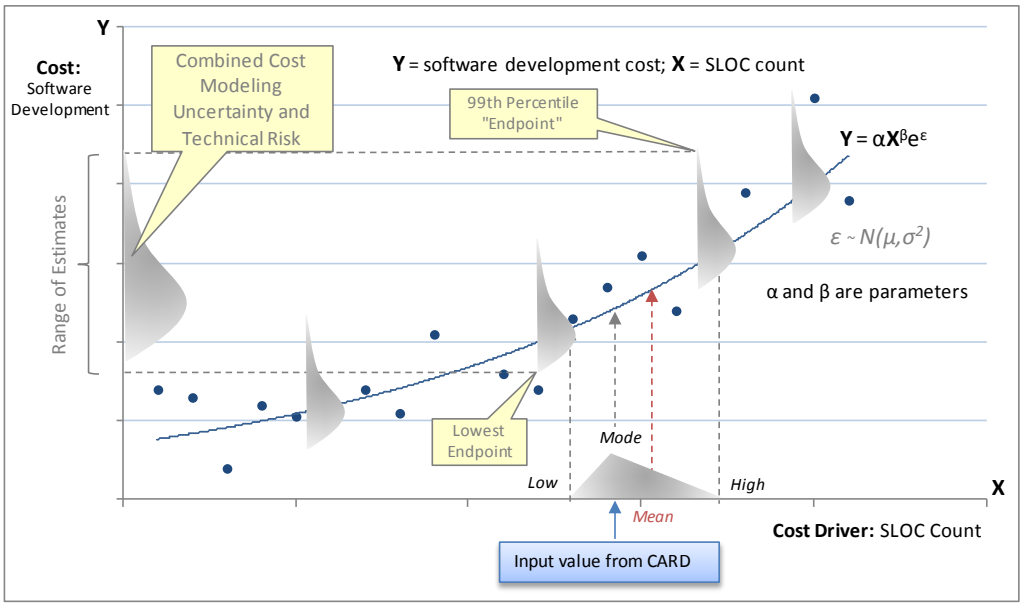

Figure 6

[14] SECNAV Instruction 5223.2A, page 2.

[15] *Risk Management Guide for DoD Acquisition*, Sixth Edition, August 2006; USD(AT&L), Systems and Software Engineering, Enterprise Development, page 33.

TOP-LEVEL ICA PBS

The ICA process breakdown structure provides a systematic and logical hierarchy of steps for performing a complete, independent cost assessment of any DON ACAT I or II program, from establishment of the ICA plan to communication of ICA results. This generic framework may be tailored, at the discretion of the DASN (Cost and Economics), to fit the unique requirements and exigencies of the acquisition program under review.

1.0 Establish ICA Plan

□ Is the ICA Plan sound?

□ Does it accord with policy parameters?

1.1 Generate Kick-Off Memo
- 1.1.1 Content of Information Request
  - 1.1.1.1 Data and Documents
  - 1.1.1.2 Initial Points of Query
- 1.1.2 Schedule

1.2 Identify ICA Resources

1.3 Ensure Compliance with Policy

2.0 Assess Need and Scope

□ Is the scope of the PLCCE consistent with policy parameters and stakeholder requirements?

□ Is scope in sync with "Big A" [JCIDS, PPBE, DAS] requirements and reviews?

□ Does PLCCE have a plan of action?

2.1 Assess Scope of Decision Space, or "Intelligence Preparation of Battlefield"
- 2.1.1 Sync with Requirements Process
- 2.1.2 Sync with Acquisition Process
  - 2.1.2.1 Milestone A
  - 2.1.2.2 Post-MS A & Beyond
- 2.1.3 Scope of Technical Effort
  - 2.1.3.1 Milestone A
  - 2.1.3.2 Milestone B
  - 2.1.3.3 Milestone C
- 2.1.4 Scope of Sustainment

2.2 Assess Accordance with Policy
- 2.2.1 Parameters

2.3 Assess Scope of Financial Analysis
- 2.3.1 Inflation
- 2.3.2 Overhead Rates

2.4 Assess Scope of CARD
- 2.4.1 Consistency

2.5 Assess Scope of Risk and Uncertainty Analysis
- 2.5.1 Choice of Method

2.6 Assess PLCCE's Master Study Plan
- 2.6.1 Completeness
- 2.6.2 Stakeholder Concurrence
- 2.6.3 Plan for NCCA Peer and Model Reviews
- 2.6.4 Initial Data Collection Plan
- 2.6.5 Initial Plan for Site Visits
- 2.6.6 Plan for Coordination with CAPE

3.0 Assess Program Baseline Definition

□ Is the baseline accurate, complete, and verified?

□ Are parameters in sync with cross checks and "Big A" [JCIDS, PPBE, DAS] documents and reviews?

□ Are measures of risk & uncertainty included?

3.1 Assess Baseline Definition
- 3.1.1 Technical
- 3.1.2 Programmatic
- 3.1.3 Operations and Sustainment

3.2 Assess Baseline Provenance
- 3.2.1 Acquisition Policy
- 3.2.2 Baseline Consistency

3.3 Assess Baseline Pedigree
- 3.3.1 Use of Cross Checks

3.4 Assess Baseline Risk and Uncertainty
- 3.4.1 PM's Assessment
- 3.4.2 Baseline Expressions
- 3.4.3 Support of eSBM Scenarios

4.0 Assess Estimate's Structure

□ Is the PLCCE WBS accurate and complete?

□ Is PLCCE WBS in sync with the baseline?

□ Does the PLCCE WBS accord with guidance?

□ Are elements of the WBS defined clearly?

4.1 Assess WBS Accuracy, Completeness, Definition
- 4.1.1 WBS Accuracy
- 4.1.2 WBS Orientation and Coverage
- 4.1.3 WBS Dictionary

5.0 Assess Ground Rules & Assumptions

□ Does the PLCCE describe and explain global and program-specific assumptions?

□ Are they consistent with other programs?

□ Do they meet stakeholder requirements?

5.1 Assess Clarity and Completeness of Identification
- 5.1.1 Global
- 5.1.2 Program Specific

5.2 Assess Validity
- 5.2.1 Provenance
- 5.2.2 Conformance with Experience

5.3 Assess Need for Analysis
- 5.3.1 Identification of Elements
- 5.3.2 Stakeholder Concurrence

6.0 Assess Data Collection/Normalization

□ Is PLCCE data collection and normalization effort accurate, complete, validated, and documented?

□ Does it support risk and uncertainty analysis?

□ Is exploratory data analysis scientifically sound?

□ Is additional information needed for the ICA?

6.1 Assess Collection Accuracy and Completeness
- 6.1.1 Collection Plan
- 6.1.2 Source of Data
- 6.1.3 Collection: Types/Sources of Data
- 6.1.4 Interpretation of Data
- 6.1.5 Documentation and Storage

6.2 Assess Data Collection for Risk Analysis
- 6.2.1 Collection Plan
- 6.2.2 Source of Data
- 6.2.3 Collection
- 6.2.4 Documentation

6.3 Assess Data Credibility
- 6.3.1 Data Currency
- 6.3.2 Applicability
- 6.3.3 Data Accuracy

6.4 Assess Data Normalization
- 6.4.1 Dimensions of Homogeneity
- 6.4.2 Documentation

6.5 Assess Exploratory Data Analysis
- 6.5.1 Data Patterns & Importance
- 6.5.2 Results of Analysis

6.6 Collect Additional Information Needed to Support ICA
- 6.6.1 Interpretation of Collected Data
- 6.6.2 Collection of New Data

7.0 Assess the Point Estimate

□ Is PLCCE built using documented, sound methods, with peer reviews and cross checks?

□ Is the PLCCE model complete, accurate, and credible?

□ Does model meet requirements while minimizing use of throughputs?

□ Do NCCA's independent cross-checks substantiate the PLCCE?

7.1 Assess Estimation Approach
- 7.1.1 Approaches
- 7.1.2 Evaluation
- 7.1.3 Prioritization
- 7.1.4 Peer Review

7.2 Assess Estimation of Major WBS Elements
- 7.2.1 Financial Parameters
- 7.2.2 Employment of Cross Checks
- 7.2.3 Examination of Quality
  - 7.2.3.1 Analogies
  - 7.2.3.2 Parametrics
  - 7.2.3.3 Engineering Build-Up
  - 7.2.3.4 Extrapolations from Actuals
  - 7.2.3.4.1 Learning curves
  - 7.2.3.4.2 Factors and averages
  - 7.2.3.4.3 EVM EACs
  - 7.2.3.5 Expert Opinion
  - 7.2.3.6 Software Estimating

7.3 Assess the Model
- 7.3.1 Requirements
- 7.3.2 Model Design
- 7.3.3 Model Documentation
- 7.3.4 Accuracy
- 7.3.5 Flexibility
- 7.3.6 Credibility

7.4 Assess Schedule

7.5 Employ Independent Cross Checks

8.0 Assess Model Tradeoffs & What-Ifs

□ Does the PLCCE model support analyses of trade space?

□ Have tradeoffs been performed to understand cost sensitivity?

8.1 Assess Supportability of Trade Space: MS A
- 8.1.1 Model Construct
- 8.1.2 Model Output

8.2 Assess Supportability of Trade Space: MS B
- 8.2.1 Technical Effort
- 8.2.2 Programmatic Effort
- 8.2.3 Sustainment

8.3 Assess Mechanics of Sensitivity Analysis
- 8.3.1 Identification of Elements
  - 8.3.1.1 Ground Rules and Assumptions
  - 8.3.1.2 Key Cost Drivers
- 8.3.2 Re-Estimation of Costs
- 8.3.3 Documentation
- 8.3.4 Repeatability and Importance

8.4 Assess PLCCE Use of Best Practices

9.0 Assess and Execute Risk Analysis

□ Does the PLCCE's analysis cover all sources of risk and uncertainty?

□ Is PLCCE risk model well-constructed, executed, and documented?

□ Do results of NCCA's independent risk analysis jibe with those of the PLCCE?

□ Do PLCCE and NCCA S-curves pass a reasonableness test?

- 9.1 Assess PLCCE Model Content
  - 9.1.1 Requirements
  - 9.1.2 Stochastic Relationships/Data
  - 9.1.3 Financial, Economic, and Programmatic Variables
  - 9.1.4 Software
  - 9.1.5 Technology
  - 9.1.6 Schedule
  - 9.1.7 Below-the-Line Elements
  - 9.1.8 Discrete Elements of Risk
- 9.2 Assess PLCCE Uncertainty Analysis
  - 9.2.1 Specification of Distributions
    - 9.2.1.1 Distribution Type
    - 9.2.1.2 Measure of Central Tendency
    - 9.2.1.3 Variance or Spread
  - 9.2.2 Track to Baseline
  - 9.2.3 Correlations
  - 9.2.4 Cross Checks
- 9.3 Assess PLCCE Risk Analysis
  - 9.3.1 Distributions of Input Values
  - 9.3.2 Specification of Risk Events
- 9.4 Assess PLCCE Model Construction and Execution
  - 9.4.1 Construction
  - 9.4.2 Execution
- 9.5 Assess PLCCE Model Documentation
  - 9.5.1 Completeness
- 9.6 Independently Execute Risk and Uncertainty Analysis
  - 9.6.1 Choice of Method
    - 9.6.1.1 Inputs Risk
    - 9.6.1.2 Outputs Risk
    - 9.6.1.3 eSBM
  - 9.6.2 Execution
    - 9.6.2.1 Monte Carlo Simulation
    - 9.6.2.2 eSBM
      - 9.6.2.2.1 Specify Scenarios
      - 9.6.2.2.2 Choose CV
      - 9.6.2.2.3 Combine CV and Point Estimate
- 9.7 Perform Tests of Reasonableness
  - 9.7.1 Compare ICA and PLCCE
  - 9.7.2 Examine Cumulative Probability of the Unfavorable Scenario

10.0 Communicate Results

□ Does PLCCE documentation allow for easy reconstruction of the estimate?

□ Are PLCCE reports and presentations clear and cogent?

□ Does the NCCA ICA report explain reasons for deltas?

□ Do PLCCE and NCCA reports highlight areas of risk?

10.1 Assess PLCCE Documentation
- 10.1.1 Completeness/Reproducibility
  - 10.1.1.1 Executive Summary
  - 10.1.1.2 Introduction
  - 10.1.1.3 Method of Estimation of Each WBS Element
  - 10.1.1.4 Method for Time-Phasing Costs
  - 10.1.1.5 Tradeoff and Sensitivity Analysis
  - 10.1.1.6 Risk and Uncertainty Analysis
- 10.1.2 Management Reports and Presentations
- 10.1.3 Clarity and Cogency
  - 10.1.3.1 Organization and Formatting
  - 10.1.3.2 Presentation of Data
  - 10.1.3.3 Presentation of Methods

10.2 Generate NCCA ICA Report
- 10.2.1 Areas of Agreement
- 10.2.2 Alternative Considerations
- 10.2.3 Basis of Findings
- 10.2.4 Independent View of Risk

10.3 Generate NCCA ICA Briefings

10.4 Present Findings

1.0 Establish ICA Plan

Successful management of the independent cost-assessment, with its complex, iterative, and interdependent activities, requires the creation and execution of a comprehensive plan of action, with milestones. Dependencies with the PLCCE-generation process need to be addressed, as well as the possibility of assessing the life-cycle costs of an *evolving*, *less-than-fully-defined* acquisition program.

The ICA plan is a necessary but not sufficient condition for project success, defined as providing Departmental leadership with a product that meets their requirements, on time, according to the points of inquiry defined in exacting detail in the subsequent steps of this Manual.

The ICA plan should specifically address:

- Initial understanding of scope and expectations
- Tasks required to complete the assessment, including interdependencies and reliance on steps in the PLCCE
- Schedule, including milestones, deliverables, and peer reviews
- Initial specification of data requirements, with details presented in the Appendix
- Resources, both government in-house and contractor support, and numbers and skill levels of team members
- Deliverables and cooperation required from other organizations.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the ICA plan sound?
- Does it accord with policy parameters?
- Does it include an initial set of required information, and queries?
- Does it indicate NCCA resources required, and their roles?

DETAILED PBS

1.1 Generate Kick-Off Memo

□ Does the ICA Plan request assistance from the program office in obtaining required information?

□ Does the ICA Plan present a schedule (events and timelines) required to meet stakeholder needs?

1.1.1 Content of Information Request [Tailored to the milestone at hand]

1.1.1.1 Data and Documents

- Program management briefings (most recent)
  - Program content
  - Program architecture
  - Program financial structure
  - Program schedule
  - Nunn-McCurdy reporting, if applicable

- Cost information
  - Historical life-cycle cost estimates for the program, or its predecessor
  - EVM Contract Performance Reports
    - Formats 1 to 5 for each of the past twelve months
    - Year-to-end for prior years
    - Selected contracts

- Requirements' documents
  - ICD, CDD, CPD, as appropriate for milestone
  - Functional Capability Board evaluation of AoA at MS A

- Acquisition documents
  - Acquisition Program Baseline
  - Work Breakdown Structure or Cost Element Structure
  - Acquisition strategy
  - Design review reports, preliminary and critical
  - Technical baseline description (CARD or CARD-like)
  - Acquisition Decision Memorandums
  - Risk Management Plan
  - DODAF views and dictionary
  - Test and Evaluation Strategy
  - Technology Development Strategy
  - Logistics Support Strategy
  - Systems Engineering Plan
  - Manpower Estimate Report
  - Test and Evaluation Master Plan
  - DAES reports
  - Selected Acquisition Reports (SARs)
  - MAIS Acquisition Reports (MARs)
  - MAIS Quarterly Reports (MQRs)
  - Cost Schedule Data Reports

1.1.1.2 Initial Points of Query

- Break down the program's budget by
  - Prime contract; major subcontracts
  - Government furnished equipment
  - Other government costs
  - Other

- Discuss any contractor teaming arrangements

- Present notional quantity profile
  - Yearly schedule
  - Development, production, FMS units

- Present overview of structure of major contracts
  - Award fee
  - Responsibility for overruns
  - Modifications

- Present overview of the program's software requirements
  - Derivation of sizing requirement and productivity factors
  - Interfaces

- Identify and explain significant cost and schedule drivers

- Identify the program's current risk drivers, and rank their criticality

1.1.2 ICA Schedule

- Key Events or Tasks
  - Steps in ICA review
  - Timeline for each
  - Tolerances (time/quality)
- Schedule Dependencies
  - Critical prerequisites for step completion
  - External factors

- Critical Points of Engagement
  - Peer reviews
  - Initial Cost Review Board
  - Preliminary NCCA ICA Report
  - Internal NCCA review
  - Pre-CRB Leadership Meeting
  - Final CRB

- Risks to ICA Completion

1.2 Identify ICA Resources

□ What resources are required to generate a quality ICA?

- Organic and contractor
- Mix of skill and experience
- Managers
- Peers, for progress reviews
- Specialized requirements
- Economists
- Engineers
- Risk experts

□ How are resources to be engaged?

- Activities
- Timeline

1.3 Ensure Compliance with Policy

□ Do ICA inputs and outputs meet quality criteria?

- Responsiveness of SYSCOMs
- Quality of CARD and other information
- Quality of ICA execution
- Management oversight
- In-progress reviews

2.0 ASSESS NEED AND SCOPE

Managing the preparation and assessment of a life-cycle cost estimate requires continual and complete coordination with all of the stakeholders or users of the product. Stakeholders may include the program office; financial, logistics, engineering, and personnel communities; and principal DON and OSD decision makers.

A critical first step is establishing expectations on the deliverable. Stakeholder requests or requirements are researched to determine the content, fidelity, and limitations of the estimate; delivery schedule; work plan; and data required by cost competencies to enable the production of a scientifically sound estimate. Results of consensus-building are documented in a *master study plan* that includes a list of tasks, responsibilities, deliverables, due dates, initial ground rules and assumptions, and points of coordination with the ICA team and the OSD CAPE.

The ICA assesses these critical elements of the PLCCE's master study plan: consistency with documents and reviews from the requirements and acquisition communities; ability to support cost/capability tradeoffs, as needed; intent to execute risk and uncertainty analysis, including recognition of the stochastic nature of inflation, labor, and overhead rates; and inclusion of a timeline for site visits, data collection, peer and model reviews with the ICA team, and liaison with the OSD CAPE.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the scope of the PLCCE consistent with policy parameters and stakeholder requirements?
- Is scope in sync with "Big A" requirements and reviews?[16]
- Does the PLCCE have a clear and robust plan of action?

[16] "Big A," a term coined by retired Air Force Major General Claude M. Bolton, Jr., refers to DoD's three decision-support systems, the Joint Requirements Integration and Development System; the Defense Acquisition System; and the Planning Programming, Budgeting, and Execution System.

DETAILED PBS

Step 2.1: Intelligence Preparation of Battlefield

2.1 Assess Scope of Decision Space

□ Is the stated scope of the PLCCE in sync with scope delineated in requirements' and acquisition documents and process reviews?

2.1.1 Sync with Requirements Process

□ Is scope of the PLCCE in sync with parameters and risks identified in the ICD, CDD, and CPD?

- Threshold and objective values
- KSAs, KPPs, other performance attributes
- For each increment or block of capability

2.1.2 Sync with Acquisition Process

□ Is scope of the PLCCE (i.e., content of program & schedule; acquisition strategy; sustainment) in sync with?:

2.1.2.1 Milestone A

- Results of Material Solution Analysis (AoA)

□ Are the alternatives operationally suitable and effective?

□ Are parameters consistent with the ICD?

□ Does scope of risk and uncertainty address:

- Technical Readiness Levels (TRLs)
- Manufacturing feasibility
- Operational issues
- System integration
- Sustainability, maintainability, interoperability
- Schedule?

□ Is scope consistent with evaluation of AoA report by

- OSD CAPE
- Functional Capability Boards

2.1.2.2 Post Milestone A & Beyond; Results of:

- Engineering and Manufacturing Development
- Critical Design Review
- Post CDR Assessment
- Issues from Technology Readiness Review
- Production Readiness Review

2.1.3 Scope of Technical Effort

□ Is scope of PLCCE in sync with results of technical documents and reviews?

2.1.3.1 Milestone A

□ Does PLCCE scope jibe with parameters from

- Test and Evaluation Strategy
- System Engineering Plan
- Initial Technology Review
- Alternative Systems Review

□ Does PLCCE scope accurately reflect:

- Degree of technical maturity
- Interoperability
- Systems Integration
- Plans for competitive prototyping and technology maturation?

2.1.3.2 Milestone B

□ Does PLCCE scope reflect results from

- System Requirements Review
- System Functional Review
- Preliminary Design Review
- Technology Readiness Assessment
- Integrated Baseline Review?

□ Does PLCCE scope jibe with parameters from

- Systems Engineering Plan
- Information Support Plan
- Acquisition Strategy Document
- Affordability Assessment?

2.1.3.3 Milestone C

□ Is scope of PLCCE in sync with results of PDR?

- DoD or NAVAIR Checklist:
  - Engineering and Product Design
  - Materials and Purchased Parts
  - Industrial Resources
  - Quality Assurance
  - Program Management
  - Software Management
  - Production and Engineering Planning

2.1.4 Scope of Sustainment

□ Is scope of PLCCE in sync with logistics and sustainment documents and reviews?

- Initial support and maintenance concepts
- Life-cycle sustainment plan

□ Does scope of PLCCE address uncertainty of:

- Sustainment metrics
- Footprint values and limitations
- Cost per operating hour
- Plans for measuring diagnostic effectiveness?

2.2 Assess Accordance with Policy

2.2.1 Parameters

□ Is scope of PLCCE consistent with policy parameters from:

- OSD CAPE
- USD(AT&L)
- ASN(FM&C)
- ASN(RDA)?

□ Does scope of PLCCE conform to requirements of all DON stakeholders?

2.3 Assess Scope of Financial Analysis

2.3.1 Inflation

□ Does scope of PLCCE reflect uncertainty of inflation rates, to include these dimensions:

- Provenance
- Intended use historically
- Intended use for outyear projections
- Rationale for using non-OSD prescribed rates?

2.3.2 Overhead Rates

□ Does scope of PLCCE reflect the uncertainty of overhead rate projections, to include these dimensions:

- Investigation of the availability, quality, and stability of forward pricing rate proposals, recommendations, agreements
- Intent to analyze alternative outyear business-base scenarios, and to generate rate forecasts accordingly?

2.4 Assess Scope of CARD or CARD-Like

2.4.1 Consistency

□ Is scope of the PLCCE consistent with the scope of the CARD to include:

- Same phases of an evolutionary or incremental acquisition
- Same elements of total ownership cost?

2.5 Assess Scope of Risk and Uncertainty Analysis

2.5.1 Choice of Method

□ Does scope of PLCCE state method for analyzing risk and uncertainty?

- Monte Carlo Simulation
- eSBM
- Sensitivity Analysis

2.6 Assess PLCCE's Master Study Plan

□ Does a master study plan guide execution of the PLCCE, and do stakeholders concur?

2.6.1 Completeness

□ Has the PLCCE team developed a master study plan, to include:

- Tasks
- Milestones
- Deliverables?

2.6.2 Stakeholder Concurrence

□ Has the PLCCE team obtained buy-in from stakeholders on the breadth and depth of the cost estimate?

- Cost competencies (SYSCOM and NCCA)
- Program Office
- Financial, logistics, engineering, and personnel communities
- SYSCOM, OPNAV, and SECNAV principals
- OSD CAPE
- ASN(FM&C)
- ASN (RD&A)

2.6.3 Plan for NCCA Peer and Model Reviews

□ Does PLCCE master plan include timeline for NCCA in-progress review of:

- Each cost-estimation step
- Cost model?

2.6.4 Initial Data Collection Plan

□ Does PLCCE study plan include requirement for collection of data?

2.6.5 Initial Plan for Site Visits

□ Does PLCCE study plan include requirement for site visits?

- Locations and timeline
- NCCA participation

2.6.6 Plan for Coordination with CAPE

□ Does PLCCE study plan include requirement to coordinate with CAPE?

- Kick-off meeting
- Data collection
- Site visits
- Reviews

3.0 ASSESS PROGRAM BASELINE DEFINITION

A good life-cycle cost estimate is based on a well-defined program. Accuracy and completeness of the definition are critical in producing an estimate that informs rather than confuses milestone decisions on DON MDAPs. A poorly defined program increases the use of assumptions and shifts the burden of uncertainty to senior leadership. The better the definition, *ceteris paribus*, the higher will be the quality, flexibility, and usability of the cost estimate.

A comprehensive baseline definition provides information on: system mission, technical and performance characteristics, legacy systems, acquisition strategy, quantities, test and evaluation plan, training plan, disposal plan, operational concept, logistics support, personnel requirements, and deltas from previous technical baselines, in addition to other data.[17]

The ICA, importantly, recognizes that a well-defined baseline does not imply complete understanding of the acquisition program. Legitimate areas of risk and uncertainty should be acknowledged and addressed. Where appropriate, especially early-on, ranges of parameter values should be provided.

The ICA further recognizes that defining the program is not a one-step-and-stop activity. It's common to refine the definition of the program throughout the estimation process.

The ICA assesses these critical elements of the PLCCE's definition of the baseline: inclusion of technical, programmatic, and operations and sustainment parameters; compliance with SECNAV policy for an independent SYSCOM technical review; use of top-level cross checks; and consistency with documents and reviews from the requirements and acquisition communities.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the baseline accurate, complete, and verified?
- Are baseline parameters in sync with cross checks?
- Are baseline parameters in sync with "Big A" documents and reviews?
- Does the baseline include measures of risk and uncertainty of parameter values?

[17] In the DON, a Cost Analysis Requirements Description is generated whenever "… a program life-cycle cost estimate is required" [SECNAVINST 5223.2A, page 6]. In theory, the CARD and associated references and attachments should contain all of the information needed by the cost analyst to generate a credible estimate. In practice, this is seldom the case, at least initially.

DETAILED PBS

3.1 Assess Baseline Definition

□ Is the program baseline, upon which the PLCCE is built, accurate and complete, along the following three dimensions?:

3.1.1 Technical

- System overview
- System performance parameters and characteristics
- Technical and physical description
- Summary of maturity levels of critical technologies
- Software description and sizing information
- Interfaces with other systems
- Subsystem descriptions

3.1.2 Programmatic

- Schedule
- Acquisition plan or strategy
- Plans for system disposal
- Summary of security or program protection features
- Summary of environment, safety, and occupational health issues
- Description of predecessor systems
- System manpower requirements
- Facility requirements
- Track to prior CARD
- Approved or proposed CSDR plan

3.1.3 Operations and Sustainment

- Suitability factors
- Reliability, maintainability, availability
- Operational concept
- Organizational structure
- Basing and deployment description
- Operating tempo
- System sustainment concept
  - Maintenance concept
  - Supply management concepts
  - Transportation concept
  - Software maintenance concept
  - System training concept

3.2 Assess Baseline Provenance

3.2.1 Acquisition Policy

□ In accordance with DON Instruction 5223.2, have CARD parameters been assessed and approved by independent technical and oversight authorities prior to submission to NCCA?

3.2.2 Baseline Consistency

□ Does the program baseline, upon which the PLCCE is built, support "Scope of the Estimate," as defined in ICA Step #2?

- In sync with acquisition documents and reviews
- In sync with requirements documents and reviews

□ Does baseline definition meet all stakeholder requirements?

3.3 Assess Baseline Pedigree

3.3.1 Use of Cross Checks

□ Is the program baseline in accordance with top-level cross checks along these dimensions?:

- Technical
  - Weight growth
  - SLOC count and growth
  - Heritage with predecessor system
  - Interoperability requirements
  - Number of links & nodes
  - Relationship of links/nodes

- Programmatic
  - Test plan
  - Schedule

- Sustainment
  - CONOPS
  - OPTEMPO

3.4 Assess Baseline Risk and Uncertainty

3.4.1 PM's Assessment

□ Does baseline include PM's assessment of:

- Program risk (Risk Cube)
- Mitigation measures?

3.4.2 Baseline Expressions

□ Does baseline indentify:

- Major risk drivers
- Expression of bounds of uncertainty for each
- Expression of consequences?

3.4.3 Support of eSBM Scenarios

□ Does baseline present initial expressions of unfavorable parameter values or events?

4.0 ASSESS ESTIMATE'S STRUCTURE

A work breakdown structure (WBS) defines, in hierarchical, product-oriented fashion, the totality of tasks required to develop, procure, and operate and support a major defense weapon system or automated information system.

Sometimes called a cost element structure (CES), the WBS divides an acquisition program into manageable groups of phases, components, and tasks.[18] MIL-STD-881C and the OSD's Operating and Support (O&S) Guide should serve as the basis for development of the cost estimate's WBS.[19,20] Some degree of tailoring may be required to capture all of the distinct characteristics or idiosyncrasies of the acquisition program under consideration. Cost elements, then, may differ slightly from program to program, even for the same platform type. Further, limitations and difficulties in data collection will inevitably influence the structure and granularity of the WBS ultimately employed in the cost estimate.

The ICA assesses the degree to which the PLCCE WBS captures and defines, accurately and completely, all elements of the life cycle, including development, procurement, and O&S.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the PLCCE WBS accurate and complete?
- Is the PLCCE WBS in sync with the baseline?
- Does the PLCCE WBS accord with guidance?
- Are elements of the WBS defined clearly?

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[18] The term "Cost Element Structure," or CES, is sometimes used interchangeably with the term "Work Breakdown Structure," or WBS. Strictly speaking, however, they're different but related concepts. A "program WBS" is a hierarchy of product-oriented elements, such as hardware, software, data, and services that collectively comprise the system. A "contract WBS" relates the elements of the program to the elements of a contract statement of work. A CES, on the other hand, defines and groups all of the costs of an acquisition program in a disciplined hierarchy whose structure is largely determined by its suitability for cost estimation, i.e., by the availability of data. Typically, the CES is based on selected WBS elements (e.g., airframe) broken down into functional categories (e.g., engineering and manufacturing labor; overhead). Finally, in a NATO cost-estimating environment, the CES is usually called a "Cost Breakdown Structure," or CBS.

[19] MIL-STD-881C, *Department Of Defense Standard: Work Breakdown Structures (WBS) for Defense Materiel Items*, 3 October 2011.

[20] *Operating and Support Cost-Estimating Guide*, Chapter 6; October 2007.

DETAILED PBS

4.1 Assess WBS Accuracy, Completeness, Definition

4.1.1 WBS Accuracy

□ Is the PLCCE WBS consistent with other work breakdown structures?

- MIL Standard 881C
- OSD CAPE "Operating and Support Cost Estimating Guide"

□ Does the PLCCE WBS reflect the program baseline?

- Technical
- Programmatic
- Operations and sustainment

4.1.2 WBS Orientation and Coverage

□ Does the program WBS…?

- Reflect a product orientation
- Contain at least 3 levels of indenture
- Reflect the specifics of the program under review
- Support the 100% rule
- Support both bottom-up estimates and top-down allocations

□ Is the PLCCE WBS of sufficient detail to support stakeholder requirements?

4.1.3 WBS Dictionary

□ Does the PLCCE/program dictionary

- Define each element
- Define how each element relates to others in the hierarchy
- Describe clearly what is included in each element
- Describe resources and activities needed to procure the element product
- Link each element to relevant technical documents?

5.0 ASSESS GROUND RULES AND ASSUMPTIONS

The Office of Program Assessment and Root Cause Analysis (PARCA) suggests that cost growth in DoD MDAPs results largely from the adoption of ambiguous or unrealistic underlying program postulates rather than from the application of faulty cost-estimating methodology.[21] Contemporary examples of inaccurate assumptions that were built into program-office cost estimates include:

- Postulate: The recurring cost of *lead-ship* construction for an amphibious assault ship will *leapfrog* the first three units on the learning curve to *unit four*, from the get-go, due to computer aided design and co-location of the government and contractor management teams.

- Postulate: COTS software for a major automated information system for Navy active-duty and reserve-component personnel will cover 60% of required functionality.

In the first case, 200% cost growth materialized instead of the presumed T1, and, in the second, the functional fit achieved at project completion was only 5% rather than 60%.

There's simply no substitute, then, for the ICA's evaluation of the accuracy, completeness, and *credibility* of ground rules and assumptions, upon which foundations the cost estimate will be built.

The ICA, at a top-level, raises these imperative points of inquiry:

- Does the PLCCE describe and explain global and program-specific assumptions?
- Are ground rules and assumptions consistent with those from other programs?
- Do ground rules and assumptions meet stakeholder requirements?

[21] "Observations from AT&L/PARCA's Root Cause Analyses," DODCAS 2012; Dr. David Nicholls; slide 5.

DETAILED PBS

5.1 Assess Clarity and Completeness of Identification

5.1.1 Global

□ Does PLCCE describe and explain?:

- Program phases and schedule
- Base year of estimate
- Assumptions regarding:
  - Labor rates
  - Inflation rates
  - Overhead rates
- GFE items and schedule for delivery

5.1.2 Program Specific

□ Does PLCCE explain and describe any and all assumptions regarding?:

- CONOPS
- Maintenance concepts
- Acquisition strategy
- Competition
- Single sourcing
- Contract types
- Multi-year procurement
- Viability of industrial base; vendors
- Quantities
- Development
- Production (LRIP and full-rate)
- Spares
- Facilities
- Savings from new ways of doing business
- Commonality or design inheritance
- Technology
- New items to be developed
- Refresh cycles
- Security considerations
- Items excluded from estimate

5.2 Assess Validity

5.2.1 Provenance

□ Does PLCCE explain the source and validity of assumptions?:

- Source (policy, guidance, direction)
- Degree of independent, SYSCOM review of their validity
- Degree of impact on major elements of cost and the possibility of inappropriate pass-through
- Degree of self-fulfilling prophecy in the case of financial variables

5.2.2 Conformance with Experience

□ Do the PLCCE assumptions conform with parameters from acquisition history?

□ If not, are reasons for uniqueness explained?

5.3 Assess Need for Analysis

5.3.1 Identification of Elements

□ Does PLCCE flag items in the GR&A list that might require what-if analysis based on:

- Degree of uncertainty
- Degree of impact on cost?

5.3.2 Stakeholder Concurrence

□ Does PLCCE offer insights into stakeholder concurrence:

- Degree of sync with stakeholder Requirements
- Requirement to address selected elements in depth
- Requirement for a certain type or depth of risk and uncertainty analysis?

6.0 ASSESS DATA COLLECTION & NORMALIZATION

Data is the raw material of cost estimating. Its collection goes hand-in-hand with building the point estimate. First, prospective methodology for estimating the cost of a WBS element drives the nature and scope of an initial data-collection effort. But inevitable limits in the availability, accuracy, currency, credibility, and understanding of data will, in turn, often require a change in methods.

As Dr. Thomas Pedersen of the Danish Defense Research Establishment cogently notes,

> *"Life cycle costing is a data driven process, as the amount, quality and other characteristics of the available data often define what methods and models can be applied, what analyses can be performed, and hence, the results that can be achieved."* [22]

The importance of data, then, is difficult to over-emphasize. The better the data, *ceteris paribus*, the higher will be the quality, flexibility, and usability of the cost estimate.

The ICA addresses these critical elements of the PLCCE's data collection and normalization effort: the collection plan; documentation of data; the degree to which primary versus secondary data are used; the currency and applicability of data; the comprehension of data mega-dimensionality, such as programmatic and mission context; the analytical techniques and inflation indices used to normalize heterogeneous data; and the application and findings of exploratory data analysis.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the PLCCE data collection and normalization effort accurate, complete, validated, and documented?
- Does data collection support risk and uncertainty analysis?
- Is exploratory data analysis scientifically sound?
- Is additional information needed for the ICA?

[22] *Methods and Models for Life Cycle Costing*, NATO Research and Technology Organization technical report of task Group SAS-054, 2006.

DETAILED PBS

6.1 Assess Collection Accuracy and Completeness

6.1.1 Collection Plan

□ Does data collection plan:

- Indentify the actions required to capture cost, technical, and programmatic information
- Ensure that every cost element is covered and mapped to WBS
- Support the current & analogous programs
- Include a projected timeline to track progress
- Support alternative methodologies?

6.1.2 Source of Data

□ Does data collection effort

- Document source of data
- Emphasize use of primary versus secondary data?

6.1.3 Collection: Types and Sources of Data

□ Does collection effort exhaust these types and sources of data?:

- Types
  - Cost, technical, programmatic, schedule, operational
  - Primary and secondary
  - Current system and information for cross checks
- Sources
  - Basic accounting records
  - Input forms from cost estimators
  - Cost and schedule reports (CSDRs, CPRs)
  - Historical databases
  - Interviews
  - Program briefs
  - Site visits
  - Contracts or contractor estimates
  - IPTs
  - Previous estimates

6.1.4 Interpretation and Comprehension of Data

□ Do the data?:

- Require normalization for inflation; i.e., different base years or types of dollars
- Differ in standard labor hours (per year or per month)
- Correspond to different work content, configuration, or composition
- Differ in programmatic or mission context
- Reflect proposed or negotiated values or actuals
- Reflect costs or prices
- Take into consideration different contract types

6.1.5 Documentation and Storage

□ Has data collection effort been documented for

- Sources
- Pedigree
- Site visits
- Interviews?

□ Have data been stored for future use and reference?

6.2 Assess Data Collection for Risk Analysis

6.2.1 Collection Plan

□ Does plan support at least one of these methods?

- Inputs Risk
- Outputs Risk
- eSBM

6.2.2 Source of Data

□ Does plan target these sources?

- Historical values
- Handbooks
- Stakeholders
- Subject matter experts (SMEs)
- Previous risk analyses
- Root cause analysis (RCA) of analogous programs
- Program office
- PEO
- Logistics community
- Engineering community
- Acquisition officials
- Studies (NCCA's CV benchmarks)

6.2.3 Collection

□ Does plan cover this detail?:

- Growth data (initial, final values)
- Data to support each stochastic cost element and input (ranges)
- Risk driver data (risk score, program size, TRL, etc.)
- Correlations (actual historical)
- Discrete risk events
- Narrative descriptions of unfavorable events

6.2.4 Documentation

- Identical to Step 6.1.5

6.3 Assess Data Credibility

6.3.1 Data Currency

□ Has data collection effort

- Noted and documented the limitations of historical data
- Emphasized information on more recent program events or acquisitions?

6.3.2 Applicability

□ To what degree are data applicable to components of the current acquisition program?

6.3.3 Data Accuracy

□ Have the data been evaluated in terms:

- Consistency
- Program context in which data obtained
- Across programs, components, phases and sources
- Completeness
- Inclusion of all elements of cost E.g., in software development cycle

6.4 Assess Data Normalization

6.4.1 Dimensions of Homogeneity

□ Has historical data been adjusted to accurately reflect differences in these areas?:

- System composition
- Hardware
- Software
- Interfaces/integration
- Procurement parameters
- Position on learning curve
- Production rate
- Facility or company
- Production breaks
- Economic and financial parameters
- Types of dollars
- Inflation
- Units of measurement
- Acquisition strategy
- Fixed versus variable
- Mission parameters
- OPTEMPO
- Operating environment
- Capabilities
- Composition of costs
- Segments of life cycle
- Blocks or increments
- WBS elements
- Infrastructure elements

6.4.2 Documentation

□ Does documentation cover degree of exactness and completeness of data?

6.5 Assess Exploratory Data Analysis

6.5.1 Data Patterns and Importance

□ Has PLCCE used scientifically-sound techniques, such as these, to explore data?

- Scatter plots
- Influence diagrams
- Classification trees
- Outlier analysis
- Data-mining algorithms
- Galaxy Charts

6.5.2 Results of Analysis

□ Do results of the PLCCE analysis:

- Suggest initial hypotheses for explaining changes in costs
- Support selection of appropriate statistical tools and techniques
- Suggest follow-on requirements for data collection?

6.6 Collect Additional Information for Needed to Support ICA

6.6.1 Interpretation and Understanding of Collected Data

- Context, composition, and comprehension
- Changes in requirements, and impact

6.6.2 Collection of Data to Support Enhanced or New Methodology

- Analogous programs, for cross checks
- Additional documents or results of "Big A" process reviews, as needed
- Additional details or drill-downs for major WBS elements, as needed

7.0 ASSESS THE POINT ESTIMATE

A number of techniques may be used to estimate the life-cycle costs of a weapon system. The suitability of a specific approach will depend to a large degree on the maturity of the program and the level of detail of available data. Most estimates are built using a combination of parametric, analogy, and engineering build-up techniques. Other methods include use of expert opinion, rules of thumb, and extrapolation from actuals. Since each technique has strengths and weaknesses, it's always a good practice to employ more than one to serve as a cross check to the others. Analogy estimates often serve in this capacity, even for mature systems.

The ICA addresses these critical elements of the PLCCE's methodology: identification and evaluation of alternative approaches of estimation; use of peer reviews; treatment of financial variables; examination of the quality of the estimate, using statistical tests, cross checks, and technical experts; assessment of the specification and statistical validity of learning curves; and design and execution of the cost model, including accuracy, completeness, flexibility, and credibility.

The ICA also continues to assess risk and uncertainty in this step, as the point estimate is developed, both in input parameters and in resulting CERs.

The ICA, at a top-level, raises these imperative points of inquiry:

- Is the PLCCE built using documented, sound methods, with peer reviews and cross checks?
- Is the PLCCE model complete, accurate, and credible?
- Does the model meet requirements while minimizing use of throughputs?
- Do NCCA's independent cross checks substantiate the PLCCE?

DETAILED PBS

7.1 Assess Estimation Approach

7.1.1 Approaches

□ Does PLCCE identify two or more approaches for each WBS item? Combinations of:

- Parametric
- Analogy
- Engineering build-up
- Extrapolations from actuals (e.g., learning curves, EVM EACs)
- Expert opinion (last resort)

□ Does PLCCE document source?

- Analogous studies
- Stakeholder knowledge
- Peer reviews

7.1.2 Evaluation

□ Does PLCCE evaluate each alternative method, based on?:

- Availability of data
- Cost of data collection
- Schedule constraints
- Prior performance with a particular estimation technique

7.1.3 Prioritization

□ Does PLCCE establish primary and secondary methods, based on each methods?:

- Accuracy
- Completeness
- Supportability

□ Does PLCCE document approach in a cost-estimating methodology matrix?

7.1.4 Peer Review

□ Does the PLCCE estimation process include a peer review to obtain additional insights?

- Knowledgeable cost analysts (e.g., TRB)
- Engineering community
- Other stakeholders

7.2 Assess Estimation of Major WBS Elements

7.2.1 Financial Parameters

□ Does the PLCCE:

- Estimate in constant dollars
- Use appropriate inflation indices
- Use appropriate outlay profiles?

□ Does PLCCE estimate independently [non-FPRA basis]

- Labor rates
- Overhead rates
- Outyear business base?

7.2.2 Employment of Cross Checks

□ Does PLCCE employ "global" or high-level cost checks?

7.2.3 Examination of Quality

□ Does PLCCE assess (ex-post) the quality of each method for each element in the WBS?

7.2.3.1 Analogies

□ Does PLCCE analyze and describe:

- Heritage of analogous program & scaling factors
- Reliability of analogous data
- Use of technical experts for scaling factors
- Similarity of parameters (old & new system) used in scaling factors?

□ Does PLCCE measure statistical distance to target system as in principal component analysis?

7.2.3.2 Parametrics

□ For each CER, does the PLCCE establish a valid statistical relationship between Y & the X's?

- Logical
- Based on analysis of any data anomalies in underlying sample
- Based on a proper normalization of data
- Developed with range of values of explanatory variables for new system in mind
- Based on acceptable measures of quality
  - R^2, SEE, F-statistic, t-statistics
- Based on relevant (recent) data

□ Does PLCCE thoroughly document each CER?

- Data sample employed
- Equation and goodness-of-fit statistics
- Discussion of CERs estimated but not used

7.2.3.3 Engineering Build-Up

□ Is PLCCE build-up based on:

- A mature detailed design
- A detailed and accurate materials and parts list
- A complete definition of each cost element
- Established industrial engineering (IE) standards and variance factors
- Inputs from experienced engineering personnel
- Inclusion of all applicable overhead, G&A, and fee data, consistent with industry standards?

7.2.3.4 Extrapolations from Actuals

7.2.3.4.1 Learning curves

□ Does the PLCCE:

- Explain derivation of equation (T1 & slope)
- Separate non-recurring and recurring to avoid double counting
- Indicate what historical data used
- Explain use of partial or equivalent units
- Explain degree/usage of commonality between variations or blocks and with other systems
- Consider rate effects
- Explore issues of multicollinearity
- Compare unit and cum average curves
- Use EVM data at least 25% complete
- Explain mappings from CCDRs?

7.2.3.4.2 Factors and averages

□ Does PLCCE explain source, accuracy, and variance?

7.2.3.4.3 EVM EACs

□ Does the PLCCE:

- Use statistical Estimate At Completion (EAC) formulae
- Compare to burn rates for analogous historical program?

7.2.3.5 Expert Opinion

□ Does PLCCE explain degree to which opinions were based on facts or data?

□ Does the PLCCE document…?

- Experience/credentials of SMEs
- Elicitation methods used
- Track record of SMEs

□ Does PLCCE use this method only as a sanity check?

7.2.3.6 Software Estimating

□ Does the PLCCE explain:

- Degree of coverage of the development effort [requirements, design, code and test]
- Degree of use of COTS, new code, modified code, reuse
- Methodology for sizing [e.g., SLOC, FPs, RICE objects]
- Productivity factors
- Software and hardware maintenance cycle
- Provenance of maintenance fees
- Conversion of labor hours to dollars
- Use of trouble reports and software change requests?

7.3 Assess the Model

7.3.1 Requirements

□ Does PLCCE model meet stakeholder requirements based on an evaluation of:

- Quantity and complexity of inputs
- Calculations
- Tradeoffs and sensitivity analysis
- Visibility and usability?

7.3.2 Model Design

□ Does PLCCE cost model allow for…?

- Flexibility
- Traceability
- Change in input parameters ("soft-coding")
- Real-time analysis ("live" calculations)
- Efficient treatment of risk and uncertainty analysis
- Cogent and clear display of outputs?

7.3.3 Model Documentation

□ Does PLCCE model documentation allow other analysts to produce estimates and updates?

7.3.4 Accuracy

□ Does PLCCE model:

- Cover all cost elements in the baseline
- Avoid double counting
- Avoid computational errors
- Generate & spread TY$ correctly?

7.3.5 Flexibility

□ Does the PLCCE model

- Allow for what-if drills
- Support risk and uncertainty analysis? [See Step # 9 for details]

7.3.6 Credibility

□ Does the PLCCE model produce credible results? Based on:

- Top-level checks
- Alternative methods
- CV benchmarks
- Independent execution of risk and uncertainty analysis by NCCA

7.4 Assess Schedule

□ Does PLCCE accurately and completely address schedule issues?:

- Composition
  - Realism of unit, system and integration testing
  - Realism of numbers of developmental, test, & LRIP units
  - Consistency with other programs
- Duration
  - Realism of concurrent developmental efforts, and overlaps with production
  - Realism of overall length in comparison with other programs

7.5 Employ Independent Cross Checks

□ Employ cross checks, using different methods than the PLCCE, for major cost drivers

8.0 ASSESS MODEL TRADEOFFS AND WHAT-IFs

The scope and substance of the PLCCE must necessarily follow in lockstep with the Department's requirements and acquisition processes as they first define and analyze cost, capability, and risk tradeoffs; develop, prototype, and evaluate technologies; and eventually decide upon the precise parameters of the material solution to produce in quantity. [23,24]

Consequently, performance of the ICA includes not only an evaluation of a life-cycle cost *point estimate*, based upon *most-likely* values in a program baseline, but, just as importantly, a thorough review and understanding of *solution space* and its evolution and refinement in JCIDS from the Initial Capabilities Document (ICD) to the Capabilities Production Document (CPD).

The ICA, then, assesses the ability of the PLCCE to perform:

- Sensitivity analyses of Key Performance Parameters (KPPs), Key System Attributes (KSAs), and "other performance attributes" in the baseline, many of which are highly stochastic and significant cost drivers;[25] and

- Tradeoffs at Milestones A and B to support OPNAV, SECNAV, Joint Staff, and USD(AT&L) affordability analyses.

The ICA, at a top-level, raises these imperative points of inquiry:

- Does the PLCCE model support analyses of trade space?
- Have tradeoffs been performed to understand cost sensitivity?

[23] "Joint Capabilities Integration And Development System," CJCSI 3170.01H, 10 Jan 2012.
[24] "Directive-Type Memorandum (DTM) 09-027 – Implementation of the Weapon Systems Acquisition Reform Act of 2009," USD(AT&L), 9 Dec 2011 [latest change]
[25] *JCIDS Manual*, 19 Jan 2012, page 36, paragraph 7.c.16

DETAILED PBS

8.1 Assess Supportability of Trade Space: MS A

□ Does PLCCE model support tradeoffs between capability, cost, and risk?

8.1.1 Model Construct

□ Does the model support a robust evaluation of solution space, as identified in the ICD & AoA, in terms of alternative threshold & objective values of:

- Key Performance Parameters
- Key System Attributes
- Other Performance Attributes?

8.1.2 Model Output

□ Does the PLCCE model

- Present ranges of costs, perhaps in step-ladders
- Highlight KPP and KSA sensitivities
- Identify capability/cost "knees in the curve"
- Present cost risk associated with critical points in tradespace?

8.2 Assess Supportability of Trade Space: MS B

□ Does the PLCCE support a robust evaluation of solution space, as identified during technology development, in terms of alternative values of technical, programmatic, and sustainment parameters?:

8.2.1 Technical Effort

- Degrees of technical maturity (TRLs)
- Manufacturing feasibility
- Interoperability
- Systems integration

8.2.2 Programmatic Effort

- Acquisition strategy and results
- Schedule
- Requirement for competitive prototyping and technology maturation

8.2.3 Sustainment

- Sustainment metrics
- Footprint size and limitations
- Cost per operating hour
- Measures of diagnostic effectiveness
- Logistics supportability

8.3 Assess Mechanics of Sensitivity Analysis

□ Does PLCCE execute the process of sensitivity analysis correctly and robustly?

8.3.1 Identification of Elements

□ Does the PLCCE identify potentially inaccurate or unstable values of parameters?:

8.3.1.1 Ground Rules and Assumptions

- Inflation rates
- Schedule
- Production quantities
- FMS quantities

8.3.1.2 Key Cost Drivers; E.g.,

- T1s
- Learning-curve slopes
- Testing requirements
- Labor and overhead rates
- SLOC count

8.3.2 Re-Estimation of Costs

□ Does the PLCCE

- Select an uncertain/unstable element to examine
- Select an alternative numerical value
  - Re-calculate cost?

8.3.3 Documentation

□ Does the PLCCE present and document the deltas in cost and the rationale for the change in input values?

8.3.4 Repeatability and Importance

□ Does the PLCCE repeat the above steps for each of the variable elements?

□ Does the PLCCE evaluate which elements are of greatest importance and sensitivity?

8.4 Assess PLCCE Use of Best Practices

□ Does PLCCE sensitivity reflect use of best practices?

- Well-documented source of factor ranges
- Use of non-arbitrary plus/minus deltas to baseline values
- Inclusion of best- and worse-case factor values
- Focus on least-understood cost elements
- Focus on high-impact cost elements

9.0 ASSESS AND EXECUTE RISK ANALYSIS

Valid techniques for conducting risk and uncertainty analysis of life-cycle cost estimates of defense acquisition programs include inputs risk, outputs risk, and the enhanced scenario-based method (eSBM).[26] The first two are almost always executed using Monte Carlo simulation. Each technique, properly used, can yield credible results.

Nevertheless, a word of caution is required. Based on research and experience in cost risk analysis, it's fair to say that the sophistication and underlying theory of many popular models and techniques often *far exceeds* the *quality* of the basic data inputs.[27] There's simply no substitute for taking the time and effort to understand the technical risks and challenges in developing and producing leading-edge defense weapon systems.

In generating realistic S-curves, all elements of risk must be included, not just some of them.[28] Distribution types and parameters must be estimated based on a careful examination of current and historical data, results of regression analyses, and elicitation of views from knowledgeable engineers. Risk and uncertainty analysis can't be relegated to an eleventh hour exercise based on *flimsy* inputs.

The ICA, both in reviewing the PLCCE and in executing risk analysis independently, addresses these critical elements: degree of coverage of stochastic elements of the work breakdown structure; provenance and pedigree of statistical distributions; use of statistically-derived correlations and cross checks; rationale for variation in the values of technical input variables; proper identification of scenarios and discrete risk events; model process flow and documentation; and use of sanity checks of overall results.

The ICA, at a top-level, raises these imperative points of inquiry:

- Does the PLCCE's analysis cover all sources of risk and uncertainty?
- Is PLCCE risk model well-constructed, executed, and documented?
- Do results of NCCA's independent risk analysis jibe with those of the PLCCE?
- Do PLCCE and NCCA S-curves pass a reasonableness test?

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[26] "Enhanced Scenario-Based Method for Cost Risk Analysis: Theory, Application, and Implementation," Paul R. Garvey, Brian Flynn, Peter Braxton, Richard Lee, *Journal of Cost Analysis and Parametrics*, 2012:2.

[27] "Portfolio Management for New Product Development: Results of an Industry Practices Study," Drs. Cooper, Edgett, and Kleinschmidt, Product Development Institute, 2001, page 20. The popular models referenced by these authors are Crystal Ball and @Risk, frequently used in defense cost analysis.

[28] "Covered With Oil: Incorporating Realism In Cost Risk Analysis," Dr. Christian Smart, Director, Cost Estimating and Analysis; Missile Defense Agency; SCEA Conference, 2011, pages 1 to 5.

DETAILED PBS

9.1 Assess PLCCE Model Content

□ Does PLCCE capture each and every source of risk and uncertainty in the estimate?

9.1.1 Requirements
- Instability, creep

9.1.2 Stochastic Relationships and Data
- Learning curves, CERs, engineering judgment and expert opinion, factors or averages, choice of analogies and scaling factors
- CER input values
- Errors in data
- Correlation

9.1.3 Financial, Economic, and Programmatic Variables
- Inflation and labor rates
- Outyear business base & overhead rates
- Acquisition strategy and outcomes
- Contract types
- Industry trends
- Programming and funding stability

9.1.4 Software
- Sizing
- Configuration
- Degree of functional fit of COTS product
- Integration effort
- Number and types of interfaces
- Refresh cycle and scope
- License fees
- Productivity

9.1.5 Technology
- Maturity
- Design challenges and stability
- Maturity of manufacturing processes

9.1.6 Schedule
- Realism
- Degree of concurrence between development and production
  - Standing army effect

9.1.7 Below-the-Line Elements
- SE/PM, data
- Peculiar support equipment
- Common support equipment
- Initial spares and repair parts
- General and administrative
- Profit or fee

9.1.8 Discrete Elements of Risk
- Program Risk Register

9.2 Assess PLCCE Uncertainty Analysis

□ Does PLCCE define the parameters of each stochastic distribution, to include their provenance and pedigree?

□ Do baseline parameter values track to CARD?

□ Are correlations employed correctly?

9.2.1 Specification of Distributions

□ For each stochastic cost element, does the PLCCE specify and explain:

9.2.1.1 Distribution Type

- Rationale for choice (e.g., t/log t for statistically-based CERs)

9.2.1.2 Measure of Central Tendency

- Identification of mean, median, mode
- Provenance or derivation

9.2.1.3 Variance or Spread

- Std deviation, variance, CV
- Provenance or derivation
- End values for triangular distributions (including adjustment of SME inputs)

9.2.2 Track to Baseline

□ Do baseline input values track to those of the CARD?

9.2.3 Correlations

□ Does the PLCCE present and explain

- Values
- Method of estimation?

9.2.4 Cross Checks

□ Does the PLCCE verify distribution types and parameters with cross checks?

9.3 Assess PLCCE Risk Analysis

□ Does PLCCE provide rationale for growth and variation in the input variables (X's) in CERs?

□ Does PLCCE define & model discrete risk events?

9.3.1 Distributions of Input Values

□ For the input variables (X's), does the PLCCE provide rationale for:

- Distribution (see 9.2.1)
- Growth relative to initial inputs for SLOC, SWAP, staffing, etc.?

9.3.2 Specification of Risk Events

□ Does the PLCCE define and model correctly a set of unfavorable or risky events, such as these?

- Inadequate understanding of software size and integration challenges
- Failure to achieve design stability
- System-to-platform integration challenges
- Number of test flights
- External parameters such as price of oil
- Others as noted in program Risk Register

9.4 Assess PLCCE Model Construction and Execution

□ Is PLCCE risk model constructed correctly?

□ Does it meet stakeholder requirements?

9.4.1 Construction

□ Does the PLCCE:

- Correctly model process flow
- Apply uncertainty and risk at appropriate elements and locations
- Avoid double counting
- Allocate risk to major cost elements?

9.4.2 Execution

□ Does PLCCE risk and uncertainty analysis?:

- Produce a risk-adjusted point estimate
- Produce a range of possible costs of the acquisition, using an S-curve
  - Display risk drivers
  - Clearly indicate:
    - Type of CV (TY$, BY$, quantity-adjusted)
    - Elements not covered in the analysis
  - Maintain consistency in presentation of S-curves
    - Same scale
    - Same dollar units
    - Same type of CV
- Compute output correlations as a model diagnostic

9.5 Assess PLCCE Model Documentation

□ Does the PLCCE document the underlying sources of all risk and uncertainty data and assumptions?

9.5.1 Completeness

□ Does documentation cover

- Statistical equations from the cost model that give estimated means and variances
- Scorecards, and derivatives thereof
- Ideas & information from subject matter experts
- Historical data and analyses?

9.6 Independently Execute Risk and Uncertainty Analysis

□ Execute risk and uncertainty analysis independently of SYSCOM

9.6.1 Choice of Method

9.6.1.1 Inputs Risk

9.6.1.2 Outputs Risk

9.6.1.3 eSBM

9.6.2 Execution

9.6.2.1 Monte Carlo Simulation

- Apply best practices
- Identify and model missing elements
- Model inflation
- Model business base & overhead
- Model acquisition outcomes
- Use historically-based correlations
- Use NCCA's S-Curve Tool in Empirical, Benchmarking modes for sanity checks, what-if drills
- Flag and explain top five elements of risk

9.6.2.2 eSBM

9.6.2.2.1 Specify and Analyze Scenarios

- Baseline, optimistic, pessimistic
- Deep-dive analysis of major elements of risk
- Extensive discussions with stakeholders
- Mind meld with system engineers
- Knowledge and application of results of analogous acquisitions

9.6.2.2.2 Choose CV

- Type of CV
- Type of platform
- Phase of acquisition
- Bounds of reasonableness

9.6.2.2.3 Combine CV and Point Estimate

□ Use NCCA's S-Curve Tool in Parametric, Benchmarking modes for sanity checks, what-if drills

9.7 Perform Tests of Reasonableness

□ Are both PLCCE and NCCA analyses reasonable?

9.7.1 Compare ICA and PLCCE

□ Are differences significant?:

- Risk-adjusted point estimates
- Risk drivers
- CVs
- Risk dollars (estimate at given percentile)
- Confidence (percentile at given estimate)

9.7.2 Examine Cumulative Probability of the Unfavorable Scenario

□ Is the cumulative probability reasonable for a plausible yet unfavorable scenario?

10.0 COMMUNICATE RESULTS

A classic maxim in the defense intelligence community states that information critical to the warfighter is not *actionable* until it is *analyzed*, *condensed*, *packaged* and *disseminated* in timely and useable fashion, into the *right* hands. The same holds true in defense cost-analysis. The salient facts and findings of life-cycle cost estimates and independent cost assessments, distilled from a mass of quantitative detail, must be communicated to senior leadership in a manner that *informs* the Department's decision calculus, on time, while demonstrating the thoroughness and professionalism of the products.

To support *meaningful* communication of study results, the ICA evaluates the quality and completeness of PLCCE documentation, and its coverage of:

- Ground rules and assumptions;
- Program background and system description;
- Data collection and normalization;
- Methodology; and
- Risk and uncertainty analysis.

The ICA memo to DON leadership, in the spirit of proffering *actionable intelligence*, spotlights the identification and evaluation of major elements of cost risk in the acquisition program. Further, the memo explains fully any cost deltas from the PLCCE for major cost drivers, to include an evaluation of: alternative methodologies and data samples; relative degrees of precision and bias; and results of tests of significance for stochastic relationships.

The ICA, at a top-level, raises these imperative points of inquiry:

- Does PLCCE documentation allow for easy reconstruction of the estimate?
- Are PLCCE reports and presentations clear and cogent?
- Does the NCCA ICA report explain reasons for deltas?
- Do PLCCE and NCCA reports highlight areas of risk?

DETAILED PBS

10.1 Assess PLCCE Documentation

□ Is documentation of sufficient quality to enable an analyst to trace, replicate, and update the estimate from raw cost data and model inputs to creation of a time-phased, risk-adjusted point estimate, by year and by WBS element?

10.1.1 Completeness/Reproducibility

□ Does documentation include these elements, in whatever grouping, and are they completely and fully explained?:

10.1.1.1 Executive Summary

- Spruill Chart

10.1.1.2 Introduction

- Composition of estimating team
- Description of the program baseline to include hyperlinks or references to files or documents that provide additional detail, such as the AoA, CARD, and CPD
- Ground rules and assumptions
- Scope

10.1.1.3 Method of Estimation of Each WBS Element

- Definition of cost element
- Set of input data, with source, interpretation, and normalization described in detail
- Cost-estimating methodology
  - Fully documented CERs, including rationale, descriptive statistics, and test results
  - Discussion of calibration factors, complexity values, and analogy scaling technique
  - Application of learning curves, including presentation of descriptive statistics, tests of significance, and calculation of equivalent units of quantity
  - Application of labor and overhead rates
  - Use of inflation indices historically and for projections
  - Use of cross checks

10.1.1.4 Method for Time-Phasing Costs

- Source/estimation of outlay profiles

10.1.1.5 Tradeoff and Sensitivity Analysis

- Variation in parameter values
  - Source and rationale
  - Impact

10.1.1.6 Risk and Uncertainty Analysis

- List or notation of all sources of risk and uncertainty
- Source or rationale for distribution types and parameters
- Source and estimation of correlations
- Explanation of S-curve
  - Type of CV
  - Coverage and limitations

10.1.2 Management Reports and Presentations

□ Are PLCCE memorandums and presentations complete and accurate?

□ Do they jibe with the cost estimate?

□ Do they explain strengths and weaknesses of the estimate?

10.1.3 Clarity and Cogency

□ Is the documentation of sufficient clarity to enable traceability of assumptions, data, and calculations back to source documents?

10.1.3.1 Organization/Formatting

□ Is the written documentation or Excel annotation laid out in logical, modular fashion?

- Top-level outline
- Consistency with steps in cost-estimating process

10.1.3.2 Presentation of Data

□ Is raw and normalized data presented, explained, and displayed, for each WBS element, in a logical, coherent fashion?

- Tables
- Scatter plots

10.1.3.3 Presentation of Methods

□ Are methods explained in conjunction with displays of the normalized data that serve as inputs?

- Rationale for the method
- Logical link to available data
- Pros and cons of the method

10.2 Generate NCCA ICA Report

□ Generate report on the results of the independent cost assessment

10.2.1 Areas of Agreement

□ Indicate elements of the work breakdown structure where NCCA concurs with the PLCCE cost estimate

- Baseline value
- Dimensions of risk and uncertainty

□ Give emphasis, in the analysis, to elements of

- Major cost
- Major criticality
- Significant risk and uncertainty

10.2.2 Alternative Considerations

□ Indicate elements of disagreement in the work breakdown structure and present alternative values

- Baseline point estimate
- Distribution type and parameters

10.2.3 Basis of Findings

□ Present rationale, for each WBS element, for agreement or disagreement with PLCCE

- Statistical tests
- Basic cost-estimating principles
- Use of different data
- Use of different analogies
- Use of different methods
- Use of different assumptions
- Bottom-up scrub

10.2.4 Independent View of Risk

□ Present a detailed report on cost risk and uncertainty of the acquisition program

- ICA view of baseline acquisition cost
  - Development
  - Production
  - Total
- ICA S-Curve
  - Reconciliation mode in NCCA S-Curve Tool
- Summary of major risk elements
  - List of top five or six
  - Explanation of each
  - Estimate of cost impact
- Deep-dive investigation
  - Top elements
  - One-page analysis of each

□ eSBM

- Same analysis but in the context of scenarios
  - Optimistic
  - Baseline
  - Pessimistic

10.3 Generate NCCA ICA Briefings

□ NCCA briefings should be clear and complete, reviewed by peers and senior leadership, and include these elements:

- Title page
- Outline
- ICA purpose (milestone or event)
- Top-level summary of the program
- Ground rules and assumptions
- Overview of total baseline acquisition costs
- ICA methodology
- ICA findings
- Areas of agreement and disagreement
- Rationale
- Impact
- Sensitivity analysis & tradeoffs, when appropriate
- Identification and explanation of cost drivers
- Independent view of risk and uncertainty analysis

10.4 Present Findings

□ NCCA presents results of the ICA in a manner that:

- Demonstrates the thoroughness and professionalism of the effort
- Shows completeness and consistency
- Explains ground rules and assumptions
- Explains differences with the PLCCE
- Conveys the stochastic nature of the estimate

ICA TOOLS

INTRODUCTION

As the Government Accountability Office notes, independent assessments often rely upon different "methods and techniques" than those employed in generating the cost estimate under review. ICA tools of evaluation and analysis include but are not limited to the ones presented in this chapter. Use of these techniques is highly recommended but not required.

DATA-MINING TECHNIQUES

- **DECISION TREES AND REGRESSION ANALYSIS**[29]

  The statistical algorithm of decision trees estimates the influence on the cost of a weapon system of a large matrix of technical and performance characteristics [100+ elements]. This top-level technique serves as an excellent cross-check to a bottoms-up estimate where only a handful of explanatory variables are employed in cost estimating relationships.

ESTIMATES BY ANALOGY

- **HIERARCHICAL CLUSTER ANALYSIS**[30]

  A sophisticated form of estimation by analogy, hierarchical cluster analysis uses a constellation of same-class programs, and vectors of technical and performance characteristics therein, to estimate the statistical distance to the targeted system. Some of the guesswork employed in the traditional method of choosing and adjusting a single analogous system is thereby eliminated. This top-level technique serves as an excellent cross-check to a bottoms-up estimate where only a handful of explanatory variables are employed in cost estimating relationships.

[29] Developed under the auspices of NATO Task Group SAS-076, directed by the Naval Center for Cost Analysis, with the United States serving as lead nation. For details, see "An Application of Data Mining Algorithms for Shipbuilding Cost Estimation," *Journal of Cost Analysis and Parametrics*, Volume 4, Number 1, 2011; Dr. Bohdan Kaluzny, et al.

[30] Ibid.

ANALYSES OF ECONOMIC VARIABLES

- **NCCA'S PARTIAL-ADJUSTMENT MODEL FOR ESTIMATING OVERHEAD COSTS**[31]

  This technique offers an alternative to reliance on forward-pricing rate proposals, recommendations, and agreements, often found in bottoms-up estimates, but of dubious long-run stability. The NCCA model is based on the notion that defense contractors desire to adjust their overhead costs to some optimal level in reaction to a change in business base, but can't do so completely in any one time period due to financial and economic conditions, institutional rigidities, technological constraints, persistence of habit, and inertia.

  The partial-adjustment model, by virtue of its construction, offers statistically-based insight on the uncertainty of overhead-rate projections, a critical component of overall program cost risk and uncertainty.

- **NCCA'S EVALUATION OF RESULTS OF COMPETITIVE PROCUREMENT**[32]

  A major hurdle in arriving at a credible estimate of the price impact of competitive procurement, in all of its manifestations, is deriving a satisfactory, hypothetical sole-source learning curve. Complicating matters is a paucity of historical data upon which to build rate and learning curves for each, individual firm in a competitive procurement. Using conservative assumptions and innovative methodology, NCCA's acclaimed work serves as a valuable cross-check to bottoms-up procedures that might be employed in the PLCCE.

- **NCCA'S CRITERIA FOR SELECTION OF INFLATION RATES**[33]

[31] "A Partial-Adjustment Model for Explaining Changes in Overhead Costs for Major Defense Contractors," Naval Center for Cost Analysis, 8 November 1995, Dr. Brian Flynn and Mr. Harold Dagel.

[32] "Results of Competitive Procurement In the 1980s," Dr. Brian Flynn and Mr. Dennis Herrin, et al, as transmitted in memo to ASN(FM&C) from, Director, Naval Center for Cost Analysis, 6 Feb 1990.

[33] Draft available from NCCA.

Risk analysis

- **Enhanced Scenario-Based Method (eSBM) and NCCA's S-Curve Tool for risk analysis.**[34]

Among the pantheon of procedures for performing cost risk and uncertainty analysis, such as Monte Carlo simulation and sensitivity analysis, the enhanced Scenario-Based Method, or eSBM, offers a unique top-level, historically-based, issue-oriented perspective. Sets of risk events, or scenarios, are defined which represent plausible alternatives to the baseline. Using CVs based on historical results of DON acquisition programs, S-curves are generated and risks assessed. eSBM can be used as a stand-alone technique to support major milestone decisions, or, as a cross-check with bottoms-up methods employed in the PLCCE.

In short, eSBM promotes realism in estimating future program costs while offering decision-makers a traceable and defensible basis for measuring risk and cost estimate confidence.

Parametric analysis

- **NCCA's Regression Diagnostics Guide**[35]

Analysis of operating and support costs

- **The Operating and Support Cost Analysis Model**[36]

OSCAM is a suite of tools that provides rapid assessments of the O&S costs of high-cost capital assets and their component systems. Using system dynamics, OSCAM represents the business processes that drive costs and their relationship to management policies in order to assess the impact of alternative maintenance strategies and operating policies on the cost and availability of these assets.

OSCAM provides a suite of models that have been developed for land, sea and air environments. Examples of the types of issues that can be investigated include:

- The impact of reliability-centered maintenance;
- The effects of lean manning;
- The impact of and strategies for contractor logistic support;
- Impact on maintenance of unintended use;
- Effects of scenarios such as warfare; and
- Alternative spares management strategies.

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[34] "Enhanced Scenario-Based Method for Cost Risk Analysis: Theory, Application, and Implementation," Paul R. Garvey, Brian Flynn, Peter Braxton, Richard Lee, *Journal of Cost Analysis and Parametrics*, 2012:2.

[35] Draft available from NCCA.

[36] Available at www.NCCA.Navy.mil.