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Affordability Engineering Framework Overview

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The MITRE Corporation

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14. ABSTRACT

The current economic environment and mounting federal budget deficits are placing considerable economic stress on the Department of Defense (DoD) and other government agencies. Investments for new capabilities, upgrades, and enhancements to existing systems as well as simple continuations of existing programs require careful analysis and evaluation of their affordability, efficiency, and effectiveness. The Affordability Engineering Framework (AEF) is being designed to help the DoD respond to these imminent fiscal realities and advance the practice of affordability engineering to improve acquisition program success. The AEF is a structured, actionable approach with tools and techniques to address affordability challenges throughout the life cycle. The AEF uses multi-disciplinary teams to quantitatively evaluate program affordability while identifying integrated cost, schedule, and performance trade space. The AEF includes four steps: an affordability risk assessment, a validation approach for coupling technical baselines and program cost estimates, a deliberate tradeoff process, and the generation of preferred courses of action with a recommendation based on a portfolio analysis methodology. The AEF can provide benefits across a wide range of acquisition programs and provide the affordability information for data-driven program decision-making. In the coming months, the AEF will be piloted and migrated across selected DoD programs for implementation with iterative evaluation and development.

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Preface & Acknowledgements

Welcome to our Ninth Annual Acquisition Research Symposium! This event is the highlight of the year for the Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) because it showcases the findings of recently completed research projects—and that research activity has been prolific! Since the ARP's founding in 2003, over 800 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 60 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a "broker" to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and hope this symposium will spark even more participation.

We encourage you to be active participants at the symposium. Indeed, active participation has been the hallmark of previous symposia. We purposely limit attendance to 350 people to encourage just that. In addition, this forum is unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. Seldom will you get the opportunity to interact with so many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. In the words of one senior government official, "I would not miss this symposium for the world as it is the best forum I've found for catching up on acquisition issues and learning from the great presenters."

We expect affordability to be a major focus at this year's event. It is a central tenet of the DoD's Better Buying Power initiatives, and budget projections indicate it will continue to be important as the nation works its way out of the recession. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you're a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

- Office of the Under Secretary of Defense (Acquisition, Technology, & Logistics)
- Director, Acquisition Career Management, ASN (RD&A)
- Program Executive Officer, SHIPS
- Commander, Naval Sea Systems Command
- Program Executive Officer, Integrated Warfare Systems
- Army Contracting Command, U.S. Army Materiel Command

- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Director, Acquisition Career Management, U.S. Army
- Office of Procurement and Assistance Management Headquarters, Department of Energy
- Director, Defense Security Cooperation Agency
- Deputy Assistant Secretary of the Navy, Research, Development, Test & Evaluation
- Program Executive Officer, Tactical Aircraft
- Director, Office of Small Business Programs, Department of the Navy
- Director, Office of Acquisition Resources and Analysis (ARA)
- Deputy Assistant Secretary of the Navy, Acquisition & Procurement
- Director of Open Architecture, DASN (RDT&E)
- Program Executive Officer, Littoral Combat Ships

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this symposium.

James B. Greene Jr.   Keith F. Snider, PhD
Rear Admiral, U.S. Navy (Ret.)   Associate Professor

Panel 22. Risk-Reduction Approaches in Acquisition Management

Thursday, May 17, 2012	
1:45 p.m. – 3:15 p.m.	**Chair: Mary Lacey,** Deputy Assistant Secretary of the Navy, Research, Development, Testing, and Evaluation ***Acquiring Enterprise Systems as a Portfolio of Real Options*** Ronald Giachetti, *Naval Postgraduate School* ***The Effectiveness of Risk Management Within the DoD*** Donald McKeon, *Defense Acquisition University* ***Affordability Engineering Framework Overview*** Scott Anderson, Virginia Wydler, and Joe Duquette *The MITRE Corporation*

Mary Lacey—Lacey is the deputy assistant secretary of the Navy for Research, Development, Test, And Evaluation (RDT&E). She is the senior civilian and serves as the senior advisor to the ASN(RD&A) for research, development, test, and evaluation, and system engineering. She has oversight responsibility for all science and engineering, test and evaluation, modeling and simulation, chief systems engineering policy, practices, and processes for ASN(RD&A).

Lacey also oversees the Department of the Navy (DoN) chief systems engineering position and the DoN deputy for test and evaluation. She is the functional acquisition workforce competency leader for systems engineering, and she is responsible for the long-term stewardship of Naval Laboratories and Warfare Centers, where most of the Navy's RDT&E capabilities reside. She serves as a liaison with industry, academia, federally funded research and developments centers (FFRDCs), UARCs, and outside agencies.

Lacey entered the senior executive service in 1996 and has 38 years of federal service.

Lacey held the position of deputy program executive for Aegis Ballistic Missile Defense (BMD). She served as the civilian executive counterpart to the program executive in creating, managing, and overseeing Aegis BMD policies, practices, organization, and mission execution. She also served as acting executive director—the senior civilian advisor to the MDA director.

Lacey served as National Security Personnel Systems (NSPS) program executive officer (PEO). She was appointed by the NSPS senior executive, deputy Secretary of Defense Gordon England, and led the comprehensive policy and program office for the design and implementation of NSPS.

Lacey was technical director of the Naval Surface Warfare Center (NSWC), where she was responsible for a business of $4.6 billion and over 16,000 employees. Lacey formerly served as the director of NSWC, Indian Head Division, which specialized in Energetics and weapons systems. She also served as head of the systems research and technology department and director of science and technology for NSWC Dahlgren Division.

Lacey began her career with the Department of the Navy in 1973 as a federal junior fellow working for the Naval Ordnance Laboratory in underwater shock testing and evaluation, advanced weapons systems, firefighting technology, and nuclear weapons safety.

Lacey earned a Bachelor of Science degree in mechanical engineering from the University of Maryland, where she also completed graduate work in control systems and explosives. Lacey's

awards include the Presidential Rank Distinguished and Meritorious Executive, DoD Distinguished Civilian Service, the Navy Distinguished Public Service, Superior Civilian Service, Women in Science and Engineering Lifetime Achievement, University of Maryland Distinguished Engineering Alumna, and the Federal Laboratory Consortium Laboratory Director of the Year. Lacey serves on the University of Maryland School of Engineering Board of Visitors, the Women in Engineering Advisory Board, and the International Council of Systems Engineering Foundation Board.

Lacey brings to her position a wealth of experience and valuable insight into civilian workforce issues. Throughout her career, Lacey has been actively involved in engineering workforce development. She continues to serve as a mentor and advisor to engineering professionals. She has proven expertise in managing large, diverse workforces and in leading and sustaining transformational change.

Affordability Engineering Framework Overview[1]

Scott Anderson—CAPT Anderson, (USN, Ret.), is currently assigned as the director for acquisition integration at the MITRE Corporation. He is responsible for integrating efforts across the company to further the objectives of affordability, efficiency, and effectiveness while improving acquisition outcomes for government sponsors. Prior to joining MITRE in 2010, Anderson served 26 years in the U.S. Navy as a P-3 patrol plane pilot, Navy test pilot, systems engineer, and major program manager. He attended the U.S. Naval Academy, graduating in 1983, and the Naval Postgraduate School from 1997 to 1999, earning master's and engineer's degrees in aeronautical engineering. He flew 3,000+ hours in 24 aircraft types and was qualified DAWIA Level III in Test and Evaluation, SPRDE, and Program Management.

Virginia Wydler—Wydler has more than 25 years of experience in federal acquisition and contracting, both government and commercial. She is a former federal employee and Navy contracting officer for major acquisitions, including Harrier Aircraft AV-8B the Defense Super-Mini Computer Program. She has also held positions with private and public consulting firms, providing acquisition and contracting capabilities with Booz Allen Hamilton and the MITRE Corporation. She holds an MS in national security strategy from the Industrial College of the Armed Forces; an MS in acquisition and contracting from the Naval Postgraduate School; and a BS in business administration from the University of Maryland. She is a certified professional contracts manager (CPCM), a fellow, and a member of the NCMA Washington, DC, Chapter.

Joe Duquette—Duquette has over 30 years of experience in leadership roles, finance, operations and program management. He is currently with The MITRE Corporation as a senior principal analyst providing economic, business, and decision analysis support to U.S. Government executives and project managers. He has also served in the U.S. Air Force as a program director, and worked for the Raytheon Company prior to joining MITRE. He holds a BA in mathematics from State University of New York and an MBA from the University of Montana.

Abstract

The current economic environment and mounting federal budget deficits are placing considerable economic stress on the Department of Defense (DoD) and other government agencies. Investments for new capabilities, upgrades, and enhancements to existing systems as well as simple continuations of existing programs require careful analysis and evaluation of their affordability, efficiency, and effectiveness. The Affordability Engineering Framework (AEF) is being designed to help the DoD respond to these imminent fiscal realities and advance the practice of affordability engineering to improve acquisition program success.

The AEF is a structured, actionable approach with tools and techniques to address affordability challenges throughout the life cycle. The AEF uses multi-disciplinary teams to quantitatively evaluate program affordability while identifying integrated cost, schedule, and performance trade space. The AEF includes four steps: an affordability risk assessment, a validation approach for coupling technical baselines and program cost estimates, a deliberate tradeoff process, and the generation of preferred courses of action with a recommendation based on a portfolio analysis methodology. The AEF can provide benefits across a wide range of acquisition programs and provide the affordability information for data-driven program decision-making. In the coming months, the AEF will be piloted and migrated across selected DoD programs for implementation with iterative evaluation and development.

Background

The current economic environment and mounting federal budget deficits are placing considerable economic stress on the Department of Defense (DoD) and other government

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agencies. As such, the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD[AT&L]) "Better Buying Power" memorandum for the acquisition community highlighted restoring "affordability" as a key objective, which has since been instantiated in policy and statute (Carter, 2010). Furthermore, the General Accounting Office (GAO) and other sources continue to report the many DoD and agency programs that are experiencing budget and schedule overruns. As a result, investments for new capabilities, upgrades, and enhancements to existing systems and simple continuations of existing programs will require careful analysis and evaluation of their affordability, efficiency, and effectiveness. Budget reductions are mandating difficult decisions about where to invest limited resources, how to make current programs more affordable, and whether to terminate poorly performing programs. There is a need for the DoD to respond to the imminent fiscal realities and advance the practice of affordability engineering for long-term acquisition improvement. A proposed approach to achieving affordability through a robust practice of affordability engineering is through the application of the Affordability Engineering Framework (AEF).

Purpose

The AEF is being developed to establish a structured approach with tools to address program affordability challenges. The AEF supports the USD(AT&L) focus on restoring program affordability via quantitative analysis of the products in the portfolio or mission area for the Technology Development Phase and trade space around major affordability drivers in the Engineering & Manufacturing Phase. The framework provides an actionable process for program managers and lead engineers to assess affordability and related risks and to develop courses of action. While useful for conducting assessments, the framework will also identify areas where affordability engineering and analysis need to be inserted in program planning and execution. Affordability principles of efficiency and effectiveness to produce value and utility need to be applied in our system engineering and acquisition management practices. The long-term goal is to provide a framework for establishing an affordability engineering competency among systems engineers in acquisition programs and activities to affect timely and efficient deliveries of capabilities to the customer.

Definitions

The following terms will be used throughout this paper:

- Affordability (At the program level)—Acquire the user need within the budget, and continue to fulfill that need throughout the life cycle of the program.

- Efficient (At the program level)—Acquire the user need in the most economical use of resources (e.g., funding, schedule, staffing). Provide greater military effectiveness for the same budget.

- Effective (At the program level)—Meet or exceed the operational need within budget and schedule.

- Program Office Estimate (POE)—Provide a detailed estimate of system acquisition and ownership costs normally required for high-level decisions. The estimate is performed early in the program and serves as the base point for all subsequent tracking and auditing purposes.

- Technical Baseline (TB)—Provide a holistic definition of the system and acquisition program accounting for all aspects that relate to cost and schedule. The TB refers, in part, to the characterization of the physical and functional representation of intended system capabilities. The core of a TB is primarily the description and decomposition of hardware, software, and integration, including non-recurring and recurring elements that make up the

system. However, much more is needed in a TB to support life cycle cost analysis in affordability engineering. Technical context (such as system dependencies, legacy capability migration and reuse, technologies, operating environment, and performance) needs to be understood. A description of the development activities, processes, resources, assets, and facilities required to engineer the system, manage the acquisition, perform test and evaluation, and ultimately deploy and sustain the system are also important components of the TB. Information assurance and other critical engineering constraints need to be translated into development activities that will be performed and contribute to the system cost. Similarly, the TB must fully describe production and operations and must support phases of the system.

- Tradeoff Analysis—Evaluate and select among system technical functions, acquisition strategy, and/or funding alternatives to achieve the desired capabilities, performance, and mission effectiveness within cost and schedule objectives.

AEF Overview

The AEF is a multi-step framework to understand a program's affordability risks and challenges and to provide approaches for achieving affordability, efficiency, and effectiveness (AE&E) in an acquisition program. Figure 1 illustrates the four steps in the framework:

- Step 1—Affordability Risk Assessment
- Step 2—Affordability Evaluation
- Step 3—Tradeoff Analyses
- Step 4—Assessment and Recommendations
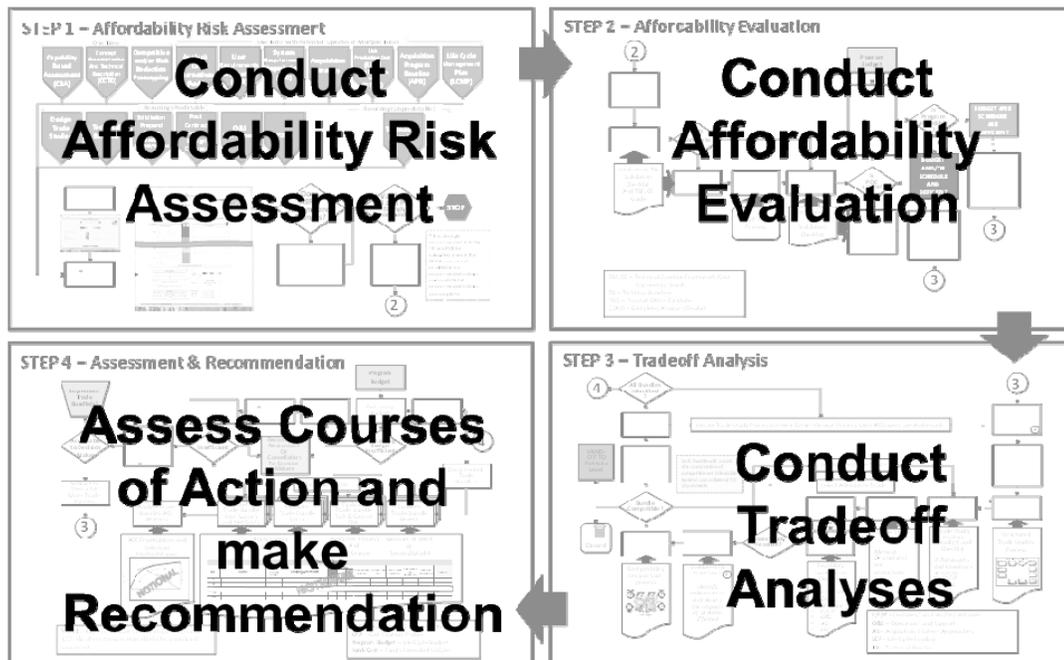
Figure 1. AEF Framework

The AEF process is conducted throughout the life cycle and initiated via "trigger" points that occur where critical program management activities and decisions are necessary.

These trigger points include periods of major program changes, budget preparation and submittal, and existing regulatory and statutory requirements for affordability certification. A typical program profile with trigger points is depicted in Figure 2.
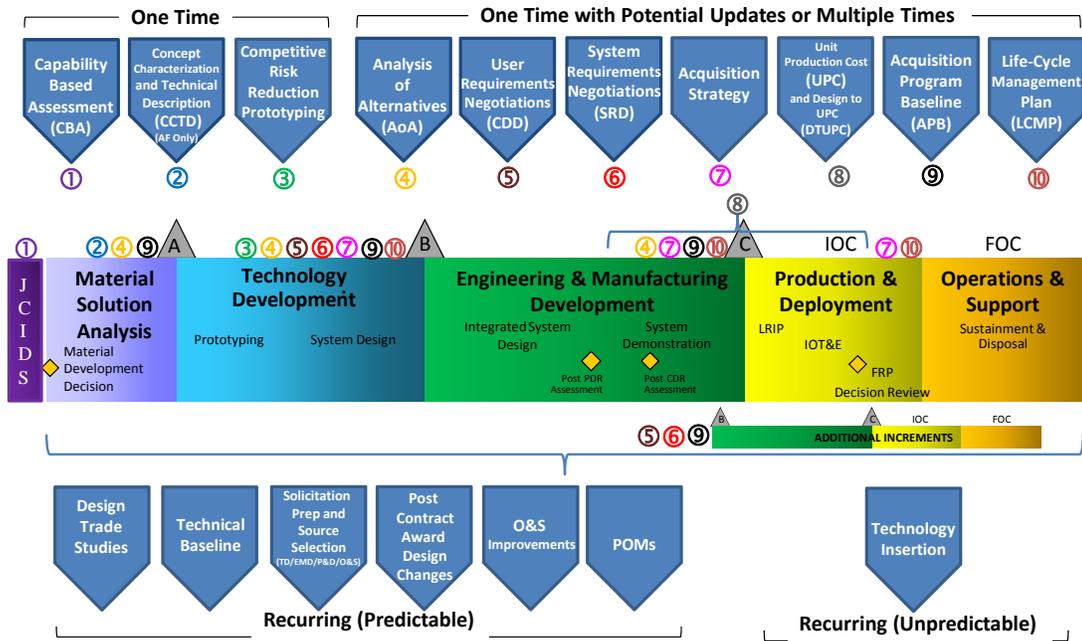
Figure 2. AEF Program Trigger Points

The AEF provides a significant increase in the number of affordability assessments relative to current requirements as there would be four or more before Milestone A and seven or more prior to Milestone B. The increase in frequency provides two major advantages: (1) stronger coherency from assessment to assessment and (2) assists in institutionalizing the importance of affordability.

Step 1—Affordability Risk Assessment

Step 1 is a qualitative assessment of the program affordability risk. The assessment is accomplished through questionnaire templates that refer to program documentation that would comprise the TB as described earlier. The assessment includes both a relative maturity measure among the various TB elements and a maturity comparison with the program phase. An Excel-based tool referred to as the Affordability Engineering Risk Evaluation (AERiE) tool is being developed to assist in the assessment task. Figure 3 illustrates the actions taken in Step 1.
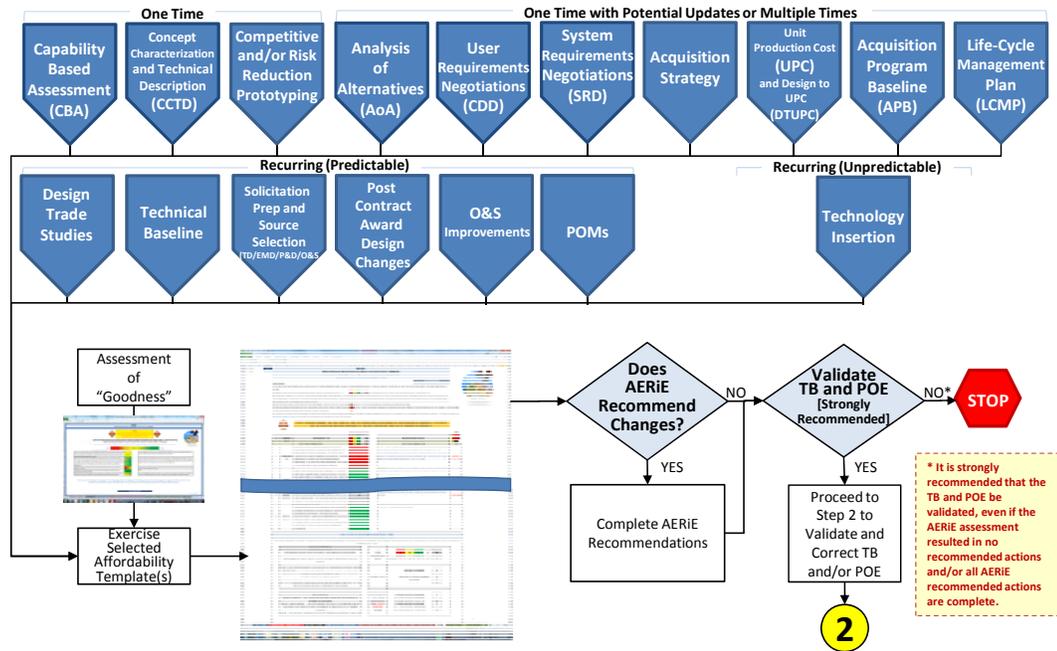
Figure 3. AEF Step 1—Affordability Risk Assessment

The first step in using the AERiE tool is assessing the program environment for managing affordability. There are five program conditions, which are guiding principles of managing for affordability and foundational to each trigger evaluation. The program team uses the following five categories of questions to assess confidence in the program management conditions.

1. Where you are in the program life cycle will establish the maturity of the TB. Given the current phase of your program, is the program TB complete and well understood? Is it updated using the best engineering experience available or using representative analogy? Is it documented in a manner that it can be used in developing sound cost estimates?

2. Again, where you are in the program life cycle will establish the fidelity of your cost estimate. Given the current phase of your program, do you believe the cost estimate is sound? Is it well-documented and based on a complete and well-indentured work breakdown structure? Was it developed using reasonable data and analogies? Does it have engineering-based inputs that include ranges that reflect program risk? Have appropriate costing methods been used? Is the program implementation based upon costs that are reflective of program risks?

3. Was the program schedule developed using the same TB as the program cost estimate?

4. Does the program have a disciplined approach to risk and requirements management supported by system engineering and associated cost analysis?

5. Are the program risk, cost, schedule, and requirements management integrated so that the cost estimates always reflect the latest risk mitigations, schedule changes, and requirements baseline decisions?

After completing program condition "goodness" checks, the program team is directed to proceed to the AERiE instruction page and begin the AERiE assessment. The program team should consider the five program conditions when rating the selected AERiE assessment templates. Each trigger has a unique affordability assessment template (see Figure 4).
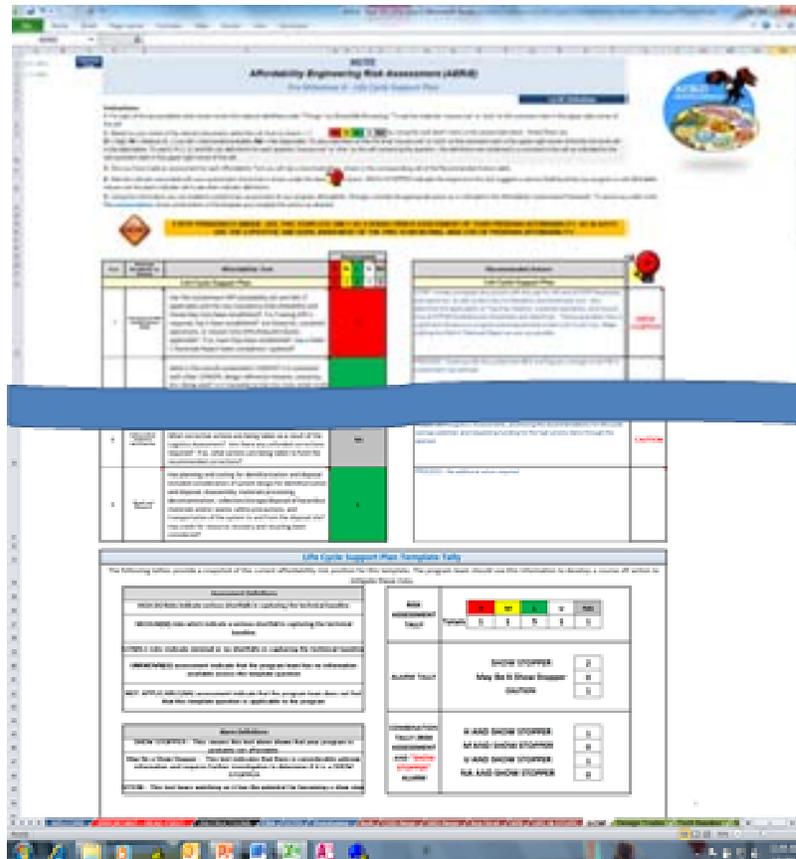
Figure 4. Typical AERiE Template

Each template contains unique assessment questions that address affordability risk indicators contained in the program's technical baseline.

For each question, the user selects a risk level (i.e., high, medium, low, unknown, and not applicable); unique risk-level definitions are provided for each trigger question. Upon selecting a risk level, the tool provides question-specific recommendations for possible corrective or mitigation actions. Unique recommendations are provided for each question's risk level. An assessment tally is provided upon completion of the assessment.

The assessment result provides the program team with evidence of risks, indicating the state of the program's affordability position. In addition, the tool warns of "show stoppers" that prevent the team from understanding the program affordability position as a result of the assessment. Corrective or mitigating changes are recommended, unless all the template questions are assessed as low risk. Once the changes are complete, the program team will validate the TB and the POE in Step 2 in the process of completing a quantitative affordability evaluation.

Step 2—Affordability Evaluation

Step 2 determines the program's affordability in a quantitative manner (see Figure 5). This is accomplished by making changes as necessary to validate the TB and the POE for completeness and accuracy. Once valid, the POE and the associated schedule are compared to the existing program budget.
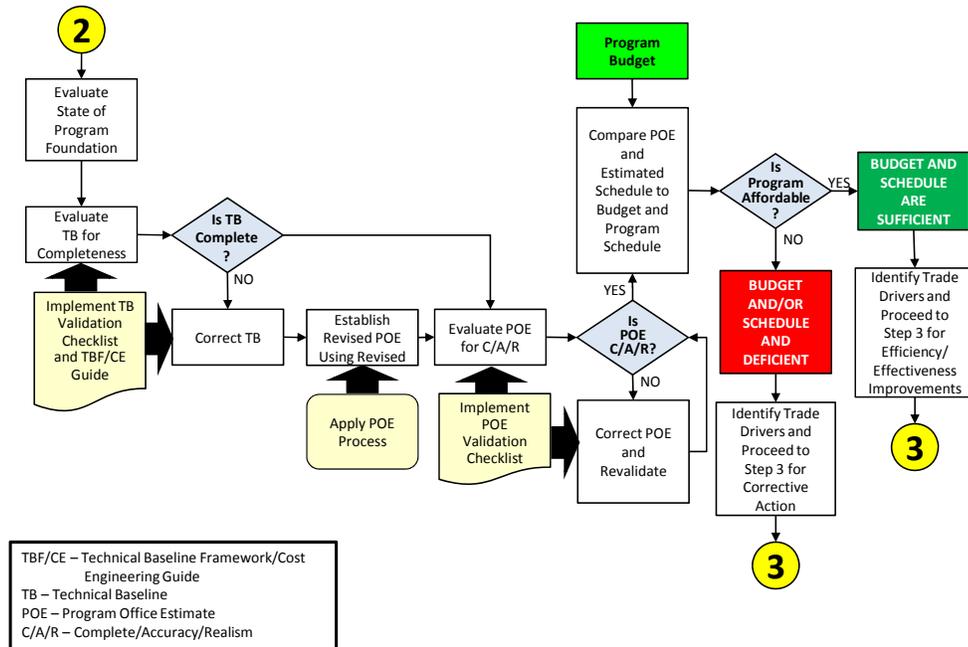
Figure 5. AEF Step 2—Affordability Evaluation

The state of the program foundation is examined before beginning the TB validation process. This ensures that the TB and POE emerging from Step 2 will be reliable. The components of this evaluation include the following:

- *Continuous Cost Engineering*—The program should have a disciplined approach to risk and requirements management, which includes tight integration of risk, cost, schedule, and requirements management and coordination with users and other active stakeholders. This will result in reliable tradeoffs and program cost estimates that reflect the latest risk mitigations, schedule changes, strategy updates, and requirements baseline decisions. As a corrective action, the program should improve affected processes (e.g., requirements definition, system design, program planning), if needed, while continuing with AEF Steps 2–4.

- *Soundness of Program Cornerstones*—The program should have acquisition artifacts and engineering and management products that are consistent with its maturity in the acquisition life cycle and the requirements of DoD Instruction 5000.02. AEF users informally consider the state of their program relative to a description of the desired elements in an acquisition and look for high-level issues. Corrective actions, if needed, include (1) improving outreach to users and acquisition stakeholders by identifying their latest needs or changed acquisition context and (2) completing or updating artifacts and incorporating changes in the TB/POE/schedule.

- *Resolution of Harmful Trends Revealed by Step 1 Affordability Risk Assessment*—An *affordability risk trend* is revealed from risks identified across different Step 1 triggers because of the coherency from assessment to assessment. The trend has an underlying cause or connection among the risks that might hinder the program in delivering affordable, timely, and effective capability to the warfighter. The revelation of a trend is accomplished by the AEF user compiling all show stopper and potential show stopper risks and studying these risks to reveal common themes/causes. The AEF will provide exemplars by program phase or milestone, relating them to alarms/recommendations from different triggers. Each trend will reveal, by the nature of the trend, the corrective action needed and the frequency with which it should be applied.

The TB is evaluated for completeness by using a *Technical Baseline Framework and Cost Engineering (TBF&CE) Guide* (*TBF&CE Guide*, 2011) in development. Evaluation of the TB involves an element-by-element comparison, illustrated in Figure 6, of the current TB to the TB checklist and the *TBF&CE Guide*, following the TB validation process.

Figure 6. TB Element-by-Element Comparison Example

The TB is valid if it is complete (i.e., contains all the elements of the TB framework), characterizes all the cost elements (i.e., contains or points to the data required to cost every element), and has the appropriate level of definition and fidelity for the point in the life cycle (i.e., reflects the maturity of the system design, sustainment approach, and acquisition strategy and portrays that maturity realistically).

If the program office has no TB or their TB is invalid, the AEF process directs corrective action to update or build a program TB. The *TBF&CE Guide* contains a "build your own workspace" template that guides the program through a specific correction to the TB or, if needed, the construction of a complete TB.

Once the TB has been validated, or corrected and validated, the program team can proceed with the evaluation and, if needed, the iteration of the POE. If the TB requires updating, the POE must be revised to be consistent with the TB changes prior to the team's validating it.

> POE—A detailed estimate of system acquisition and ownership costs normally required for high-level decisions. The initial estimate is performed early in the program. It serves as the base point for all subsequent tracking and auditing purposes.

Then the POE is valid if it is complete (i.e., estimates costs for all elements of the TB), realistic (i.e., identifies costs considering available data), and reasonable (i.e., accounts for TB assumptions and associated risks).

The POE is evaluated using the *POE Validation Guidance (PVG)*[2] and products derived from the guide (e.g., *Program Office Estimate Validation Process* and *Program Office Estimate Validation Checklist*).

If the POE is not valid, the AEF process directs corrective action to update the POE and revalidate, if required. This activity is iterative and intended to reveal information that may require additional updates to the TB.

Once the POE is validated, the AEF process directs a comparison with the program budget. With a validated TB and POE, the POE and estimated schedule are compared to the program budget and program schedule.

- *Program is affordable.* If the budget or program schedule is sufficient relative to the POE and estimated schedule (i.e., the program is affordable), the program team can exit the process or continue to Step 3 (recommended) for discovering potential efficiency and effectiveness improvements.

- *Program is unaffordable.* If the budget and/or program schedule is insufficient relative to the POE and estimated schedule, the program team will proceed to Step 3 to identify corrective action alternatives and potential efficiency and effectiveness improvements.

The validation of the TB and POE will reveal technical, performance, schedule, acquisition, and/or logistics drivers of the program. These elements have a strong influence on the feasibility and affordability of the program. These drivers may directly or indirectly drive the program's cost and schedule or impose risk that should be mitigated. Leaving Step 2, the program team will have identified the program effectiveness and cost drivers as well as a quantitative affordability evaluation. These program drivers will become the subjects of tradeoff analyses conducted in Step 3.

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[2] *PVG* is a set of authoritative cost-estimating and evaluation documents that have been placed in the MITRE SEPO *Cost Estimating Toolkit.*

Step 3—Tradeoff Analyses
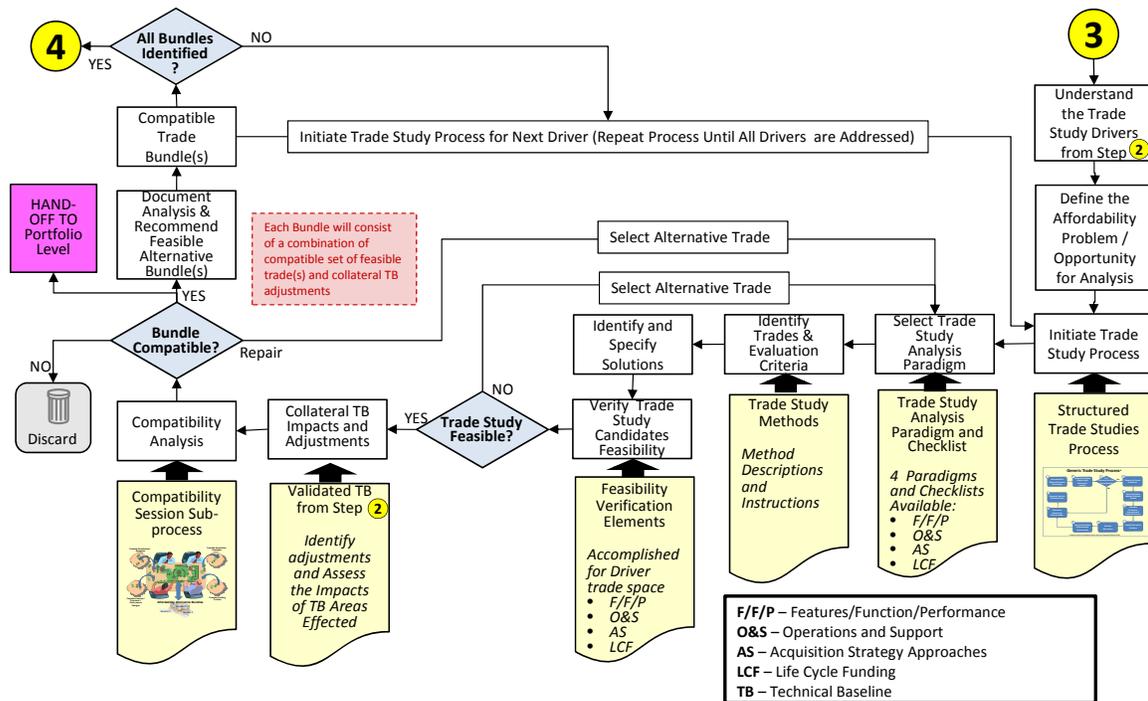
Figure 7. AEF Step 3—Tradeoff Analyses

Step 3 is designed to develop and conduct structured tradeoff analyses and walks the program team through a deliberate process. Much of this step is formative to the tradeoff analysis process, identifying, structuring, evaluating, and determining candidate trade studies that should move to Step 4 for final analysis.

> Tradeoff Analysis—The process of evaluating and selecting among system technical features, acquisition strategy, and/or funding alternatives to achieve the desired capabilities, performance, and mission effectiveness within cost and schedule objectives.

In Step 3, the program team reviews the trade study cost and effectiveness drivers that were identified in Step 2. This ensures that the team understands the affordability issues/challenges and/or AEE opportunities with a program life cycle perspective.

For each of the drivers, the user defines the integrated (cost, schedule, performance) trade space[3] that needs to be examined and the candidate trades that may exist in that trade space. If the budget or program schedule is sufficient relative to the POE and estimated schedule (i.e., the program is affordable), the user will focus on trade opportunities that can be analyzed to achieve cost savings/avoidance and/or to improve the effectiveness of the system required. If the budget or program schedule is insufficient relative to the POE and estimated schedule (i.e., the program is unaffordable), the user will focus on cost/schedule reduction trades that will allow the program budget to be sufficient (i.e., deliver the warfighter capability within the program budget). The generic trade study process is shown in Figure 8.

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[3] Trade Space—The multivariable set of fiscal, temporal, legal, political, operational, sustainment, program and system parameters, attributes, and performance characteristics required to satisfy user needs that are used by decision-makers to make informed and structured program or portfolio decisions.
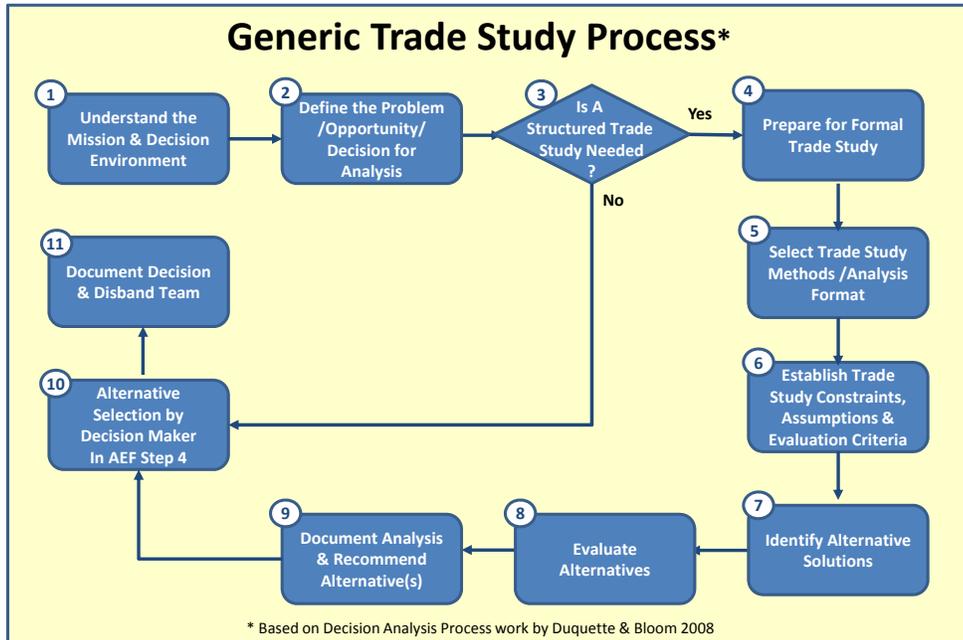
Figure 8. Generic Trade Study Process

The trade study process is an overarching process for Step 3. Detailed actions are specified for each step to guide the program team through a rigorous evaluation of the trade alternatives. The next series of actions in Step 3 is the first stage of the trade study analysis.

The user first selects the Trade Study Analysis Paradigm and Checklist.[4] Four paradigms and checklists will be available for the program team:

- Features/Functions/Performance (F/F/P)
- Operations and Support
- Acquisition Strategy
- Life Cycle Funding

The user then identifies the trade options and selection criteria through a set of defined methods. For example, one trade in F//P might be a non-development item (NDI) versus development.

The next action (Step 9 in Figure 8) specifies a set of alternative solutions that will satisfy the challenges/issues and/or opportunities posed by the driver.

The tradeoff alternative solutions are then evaluated for feasibility and compatibility.

A feasibility determination is accomplished by using *feasibility verification elements*. Figure 9 is an example of the feasibility verification elements for an acquisition strategy. For example, if the production approach (Number 13) is far left or right on the scale, the acquisition strategy trade is significantly constrained.

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[4] The Trade Study Analysis Paradigm and Checklist provide the context and actions necessary to carry out a trade study for the four paradigms.
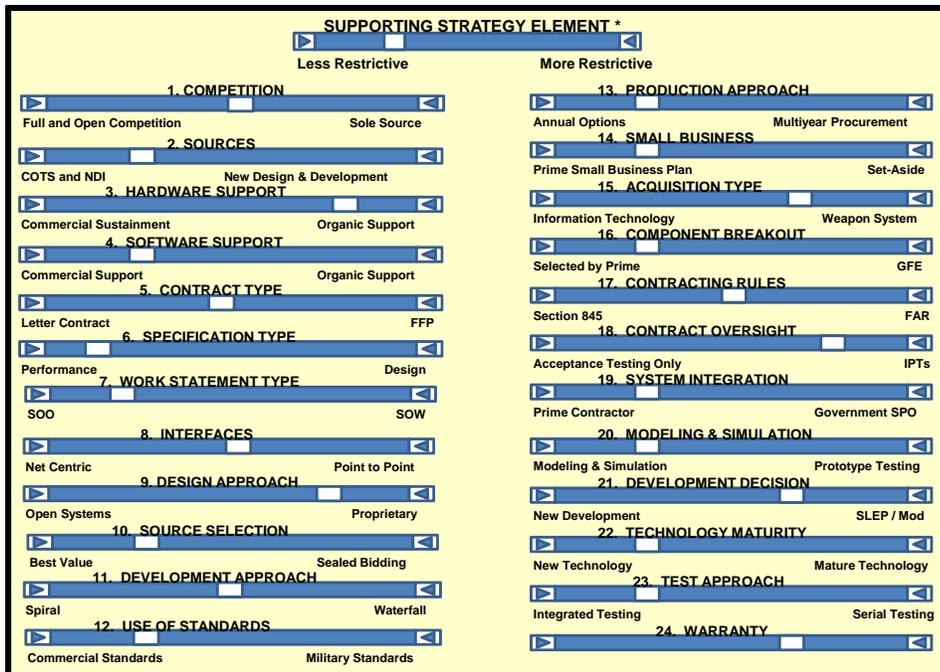
Figure 9. Tradeoff Alternative Feasibility Verification Example

If the trade is not feasible, the program team selects an alternate trade. If the trade study is feasible, a compatibility check against the validated TB is performed. The program team identifies adjustments to the TB, enabling the specific trade and its alternative solutions. For example, if the trade is an F/F/P trade, adjustments may be required to the acquisition strategy, sustainment strategy, funding profiles, and so forth to implement the alternate solutions. All collateral impacts and adjustments to the TB relating to the trade are identified.

Compatibility is now evaluated by subject-matter experts. The process determines tradeoffs that need to be bundled due to coupling among individual trades. The changes to the TB are also determined. Each tradeoff bundle will consist of a combination of compatible feasible tradeoffs (i.e., the applicable set of the four Trade Study Analysis Paradigms and their collateral TB adjustments).

Tradeoff bundle elements are compatible if the combination of feasible trades and collateral TB adjustments provide a workable alternative to the existing condition. If the tradeoff bundle is compatible and can be implemented at the program level, the next action in Step 3 is to document the analysis and the recommended feasible tradeoff bundle. If the tradeoff bundle is better suited to a portfolio implementation, it is deferred to the portfolio level for consideration. If the tradeoff bundle is not compatible, it is revised, if possible, and reevaluated for compatibility.

The user repeats the Step 3 process to generate feasible and compatible tradeoff bundles for each of the cost and effectiveness drivers that were identified in Step 2.

Step 4—Assessment and Recommendations

The objective of Step 4 (Figure 10) is to select efficiently and effectively the tradeoff bundles that deliver the capabilities that the end user needs within the established budget and time line. These recommendations are based upon benefit, risk, cost, and schedule impacts.
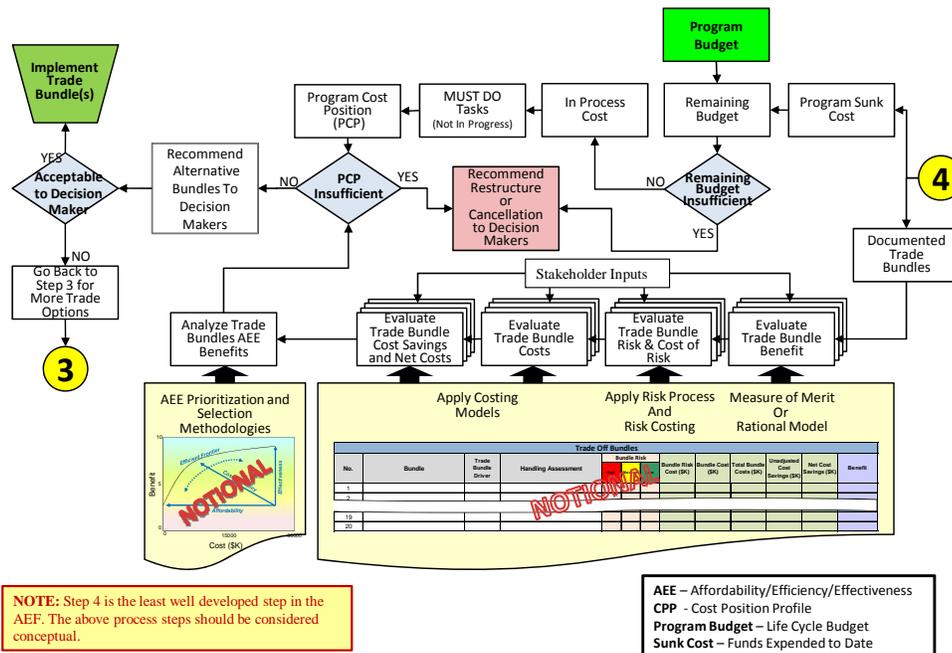
Figure 10. AEF Step 4—Assessment and Recommendations

If the program was determined unaffordable in Step 2, the program team assesses feasibility/effectiveness of the various trade bundles established in Step 3 to define an affordable program. If the program was determined affordable in Step 2, the program team will evaluate the tradeoff bundles to improve the affordability position of the program through improvements in efficiency and effectiveness.

Recommendations are made by considering the tradeoff bundles' or set of bundle alternatives' ability to meet affordability goals, efficiency in meeting these goals, and the effectiveness in delivering needed mission capabilities.

In Step 4, conducting the analysis of each tradeoff bundle requires the following costing and evaluation activities:

- evaluate the risk of the trade bundle by applying the program risk management process,[5]
- determine the costs associated with the risks identified in the bundle,
- determine the cost and risk of implementing the tradeoff bundle,[6]
- determine net cost savings if the bundle was implemented, and
- determine the benefit of the bundle.

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[5] Use the risk management process like the following: http://www.mitre.org/work/sepo/toolkits/risk/
[6] *Bundled risk cost* can be evaluated with Paul Garvey's (2012) *Measuring Economic Returns of Risk-benefit Tradeoffs in System Acquisitions—An Affordability, Effectiveness, and Efficiency Perspective.*

There are a variety of assessment tools being evaluated that can be adapted to evaluate the cost, risk, and benefit data that has been developed in this step. Available tools include the following:

- Portfolio Analysis Machine (PALMA™),
- Desk Top Return on Investment,
- Kepner-Tregoe Method, and
- Investment Portfolio Analysis Model (IPAM).

The relationships/dependencies among AE&E are illustrated on a cost-benefit graphic in Figure 11. The Figure 11 efficient frontier curve describes the most efficient state possible for a given benefit/cost combination. The trade space is the area of the graphic bounded by the efficient frontier and the effectiveness and affordability vectors. The objective is to move in the direction of increased efficiency, which can be quantitatively measured by the assessment tools identified earlier. Devising solutions to address affordability challenges requires understanding what drives each dimension and how developing alternatives in the different tradeoff paradigms can move a program along a specific vector. The AEF is being designed to enable exploration of this AE&E trade space while providing how-to guidance for identifying and addressing affordability.
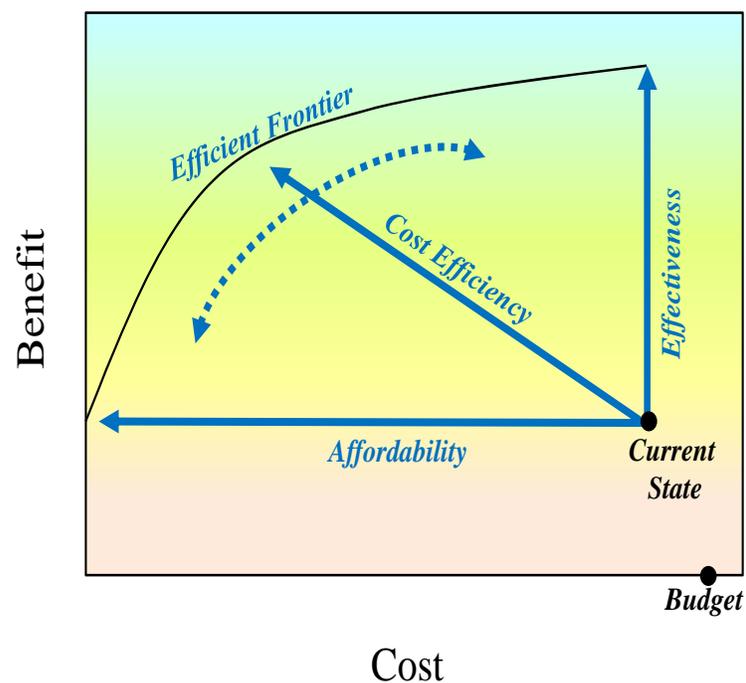
Figure 11. AE&E Relationships

The bundled tradeoff alternatives are evaluated against the program cost position for improved efficiency and affordability. Recommendations are provided to decision-makers for determination. If the decision-makers accept the recommended set of alternative tradeoff bundles, the program team designs the implementation.

Status and Implementation of the AEF

The AEF development is planned to be completed by September 2012. The step-wise framework permits incremental evaluation via "piloting" within existing acquisition

programs prior to completion. The piloting activity is planned for June through September 2012 within representative programs across the Navy, Army, and Air Force. To facilitate the piloting, a quick-start guide will be developed.

The actual implementation will vary from program to program but will have the following common tenets:

- a single technical baseline definition for cost, schedule and performance planning, modeling, executing, and reporting,
- incorporation of cost and schedule into the traditional engineering trade space,
- leverage of the integrated trade space to develop bundled tradeoff alternatives for program decision-makers,
- actionable framework with appropriately detailed tools, and
- execution via integrated system engineering and cost analyst teams.

The program systems engineering and financial management processes will require modification for implementation of these tenets. As with most changes, successful implementation will require priority from program leadership. The AEF crosses multiple disciplines and should be led by the program manager (PM). The outcome of a successful AEF implementation is an execution that will be measurably more efficient in the dimensions of affordability (cost) and effectiveness (benefit).

Summary

The AEF is designed to provide a rigorous approach for proactively achieving program affordability. The AEF supports the USD(AT&L) mandate to restore acquisition program affordability and control cost growth. It does so by a multi-step process that qualitatively and quantitatively measures program affordability risk, developing a set of targeted tradeoffs that are bundled, evaluated for compatibility, and then recommended for implementation. The AEF is designed to be actionable with tools and templates to guide program teams during execution. The AEF is conducted in a manner that increases the frequency of affordability assessment to improve assessment quality, with integrated multi-disciplinary program teams to institutionalize the management of integrated cost, schedule, and performance trade space. The primary objective is to increase the probability of program success in a challenging budget environment through increased execution efficiency throughout the life cycle and provide program managers with data-driven rationale for program change recommendations.

References

Carter, A. B. (2010, June 28). *Better buying power: Mandate for restoring affordability and productivity in defense spending* [Memorandum]. Washington, DC: USD(AT&L).

Crawford & Dello Russo. (2011, September). *The Technical Baseline Framework and Cost Engineering Guide* (MP-TBD).

Garvey, P. R. (2012, February 28). *Measuring economic returns of risk-benefit tradeoffs in system acquisitions—An affordability, effectiveness, and efficiency perspective.* The MITRE Corporation.

Program Affordability Engineering Framework (AEF)

NPS Acquisition Research Symposium
Panel Discussion

17 May 2012

Scott Anderson
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MITRE

Overview

- **Program Affordability is of paramount importance in the current fiscal environment.**

- **MITRE's Affordability Engineering Framework (AEF) Project aims to develop a systems engineering process to address Program Affordability.**

  – Goal: Shape program to achieve BBP "should cost" and address affordability challenges.

  – Maturity: ~60% overall; development scheduled to complete Sep '12.

  – Currently identifying pilot programs to shape and validate AEF tools and techniques.

The AEF can benefit the PMO by providing an actionable process to proactively manage program affordability.

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AEF Objectives

Provide a standardized, actionable, systems engineering approach to make programs more affordable in execution.

- **Improve government program technical and budget planning.**
  - Develop a government technical reference design.
    - Requirements feasibility, cost/performance modeling, RFP preparation and proposal evaluation.
- **Reduce "uncertainty" in cost-estimating to mitigate affordability risk.**
  - Build a comprehensive program baseline based on the reference design – "Acquisition Systems Engineering Baseline" – similar to CARD.
  - Frequently iterate the ASE baseline as a "living document" to tightly couple PMO cost analysis and technical activities.
- **Develop integrated program trade-space for cost, schedule and performance to construct COAs to address affordability.**
  - Provide data driven analytical products for more accurate and defendable PMO cost positions and trade offs.
  - Emphasize integrated systems engineering and cost estimating activities.

Institutionalize "cost consciousness" in PMO decision-making.

The Affordability Engineering Framework

- **Multi-step process conducted iteratively throughout the program lifecycle.**

STEP 1 – Affordability Risk Assessment

1. Conduct Affordability Risk Assessment

STEP 2 – Affordability Evaluation

2. Conduct Quantitative Affordability Evaluation

STEP 4 – Assessment & Recommendation

4. Evaluate, Select and Implement COA

STEP 3 – Tradeoff Analysis

3. Conduct Tradeoff Analyses

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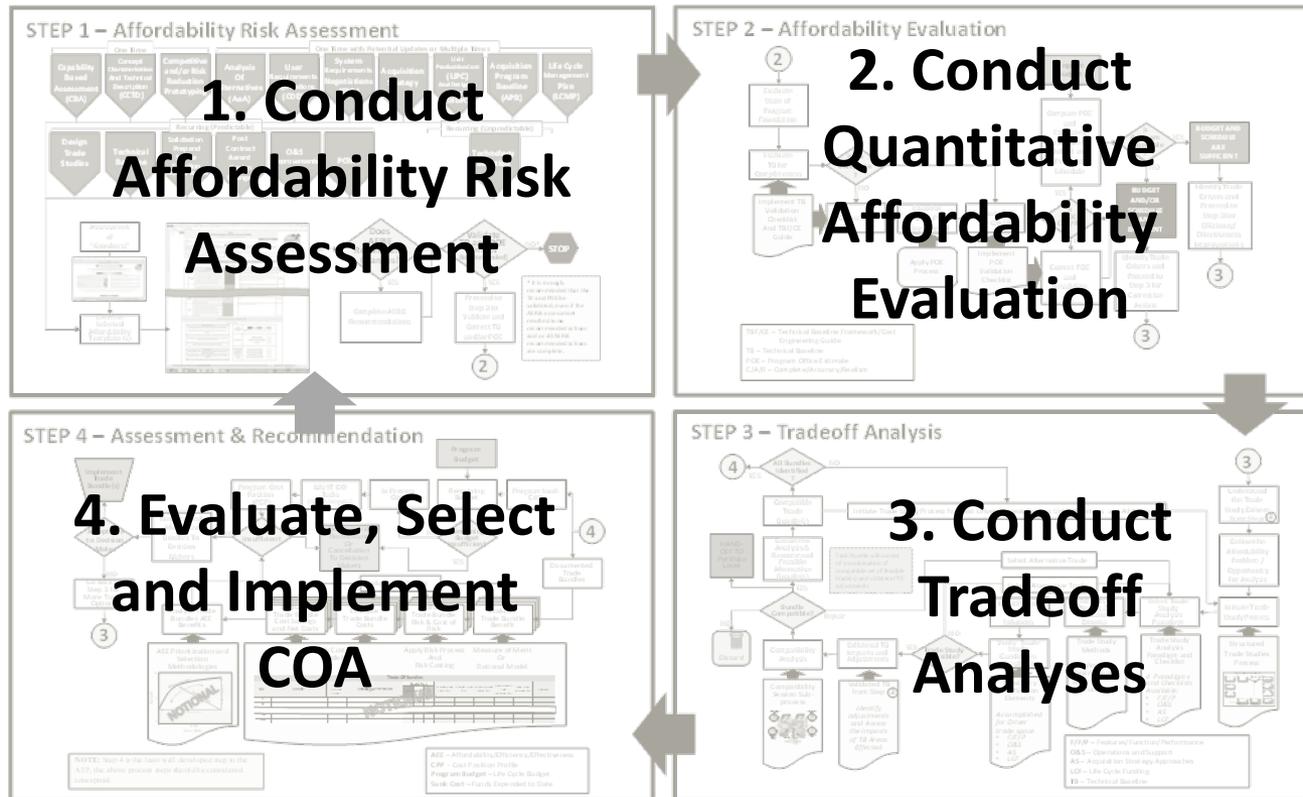
AEF in the Program Lifecycle

- **AEF initiated by "triggers" that map to critical acquisition engineering/management activities and decision points:**
  - Program changes
  - POM cycles
  - Regulatory and statutory requirements
- **More frequent assessments** (beyond the current regulatory and statutory requirements) **designed to provide better affordability "situational awareness" and coherency between measurements.**
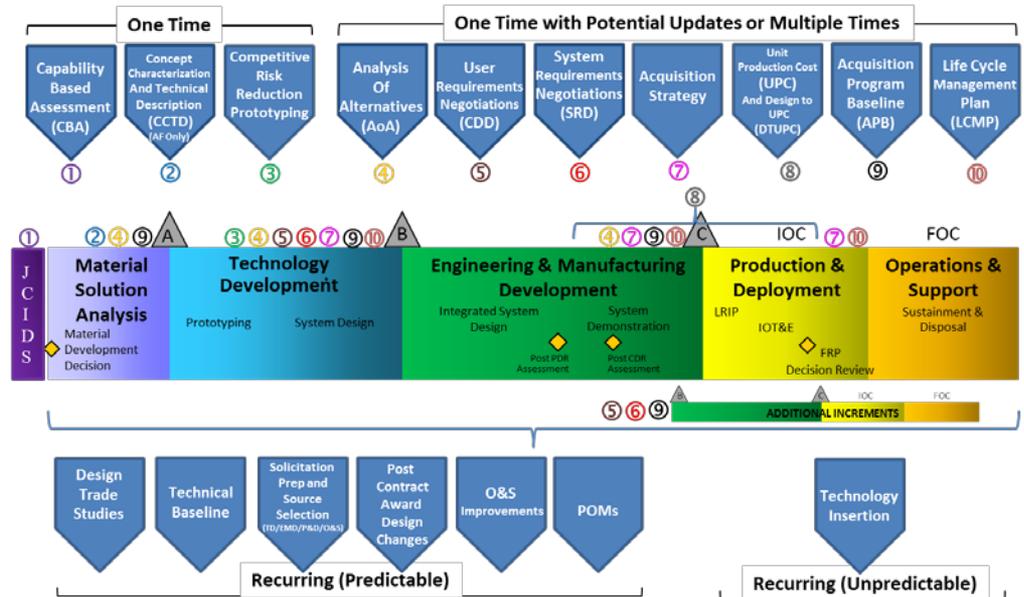
Increased affordability "situational awareness" for improved program decision-making.

AEF Step 1 – Affordability Risk Assessment

Affordability Engineering Risk Evaluation AERiE Tool

- ❑ "Quick look" using an excel-based tool – "AERiE" .
- ❑ Templates designed for each "trigger" point derived from lessons-learned and SME recommendations.
- ❑ Interview and evaluate program information/documentation…
  - ➢ "Maturity Assessment": Content detail?
  - ➢ "Confidence assessment": Process and content quality?

- ❑ Output(s):
  - ➢ *Affordability Risk Assessment.*
  - ➢ *Partial Acquisition Systems Engineering (ASE) Baseline (analogous to DoD CARD data)*

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AEF Step 2 – Affordability Evaluation
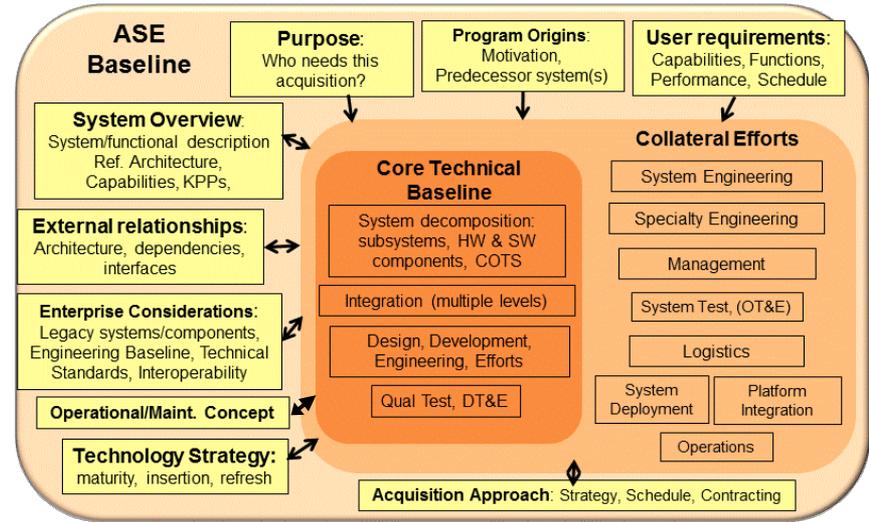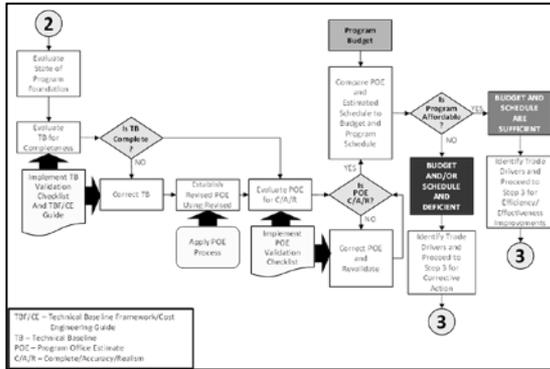
- ❑ Conduct quantitative evaluation of the program affordability
- ❑ Assemble a comprehensive "Acquisition Systems Engineering (ASE) Baseline". ..similar to CARD.
- ❑ Emphasis on:
  - ➢ Multi-discipline Teams
  - ➢ Detailed Core Technical design
  - ➢ Risk mitigation.
  - ➢ Modeling.
  - ➢ Program Interdependency.
  - ➢ Acq Strategy.

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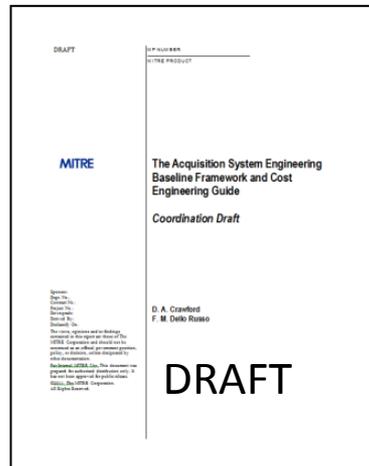
- ❑ Evaluate and iterate the Program Office Estimate (POE).
- ❑ Compare the POE to the existing program budget.
- ❑ *Outputs:*
  - ➢ *Quantitative affordability position.*
  - ➢ *Completed ASE Baseline and POE.*
  - ➢ *Integrated C/S/P trade space.*
  - ➢ *Cost drivers and uncertainty.*

AEF Step 3 – Tradeoff Analysis
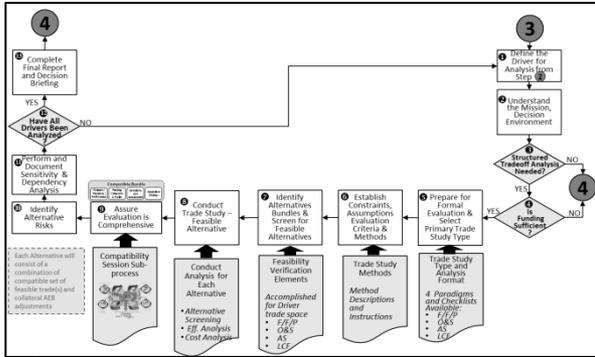
- Leverage integrated C/S/P trade space to develop and analyze trade offs.
- Structured trade study analysis process: constraints, assumptions, evaluation criteria, weighting.

- Tradeoff types determined by primary driver:
  - Features, functions, performance
  - Operations and support
  - Acquisition strategy
  - Life Cycle Funding
- Each tradeoff is measured for:
  - Effectiveness
  - Cost
  - Schedule
  - Risk scoring
  - Sensitivity analysis
  - Dependency (i.e., change compatibility)
- *Output:*
  - *Tradeoff Analysis Summary Table*

Tradeoff Alternatives Analysis Summary Table

AEF Step 4 – COA Selection and Implementation

Under Construction
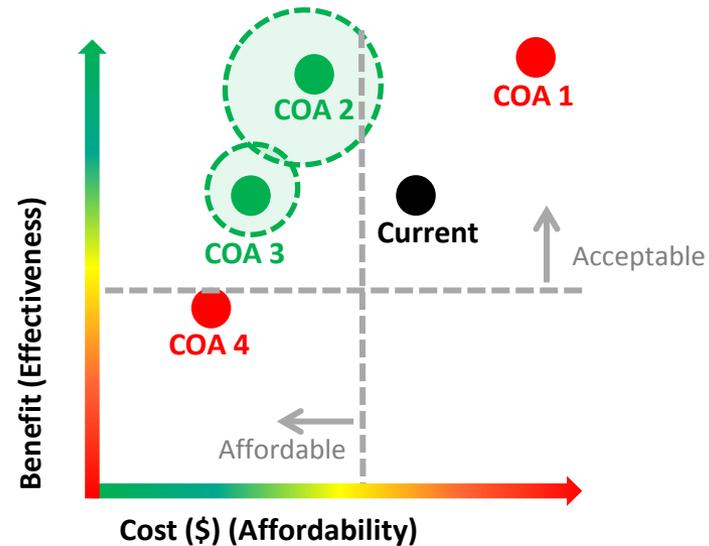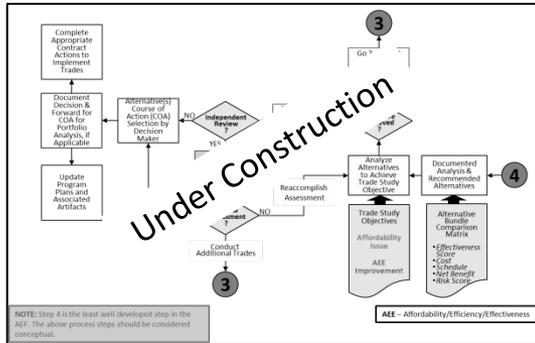
- Evaluate the candidate COAs for: affordability targets, mission effectiveness, and efficiency.
- Benefit scores are normalized values from decision factors.
  - Acceptable score determined from effectiveness measures.
- Cost score from analyses .
- Both benefit and cost scores incorporate uncertainty ranges.

- Select a COA and develop the implementation plan.
- *Output:*
  - *Decision to execute Course Of Action to achieve affordability objective.*
  - *Initial implementation plan.*

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Takeaways to Improve Program Affordability

Institute a data-driven SE process to measure program affordability and manage to "should cost".

- **Develop and maintain a government reference technical design to strengthen government program technical team.**
  - Use for requirements realism, cost estimating/modeling, proposal risk evaluation.
- **Use a comprehensive "costable" program baseline (e.g. CARD or ASE) and iterate it frequently to maintain an accurate cost estimate.**
  - Align cost models, technical configurations and performance models.
- **Develop and leverage integrated C/S/P program trade space for COAs to respond to budget challenges.**
- **Conduct the process with integrated Systems Engineering and Cost Analysis teams.**

Adopt a rigorous Affordability Engineering approach to "*exercise more disciplined use of defense dollars*".

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Back-Up

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AEF Step 1 – Affordability Risk Assessment

AERiE Tool

Lifecycle

Maturity Assessment

Acquisition Systems Engineering Baseline

Baseline Elements

Confidence Assessment

Chart Legend

Can't Reasonably be Defined	
Assumptions	
Early Approximation	
Preliminary Definition	
Improved Definition	
Stable Definition	

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31			applied in production cost	**Risk Levels for this Test:**
	10	Risk Management	Is the risk management system described in the acquisition strategy managed independently by the Government?	**H** = The risk management system is performed by a prime contractor or another organization with a pecuniary stake in the actions of the risk management team. **M** = There is some form of jointly run risk management between the Government and a contractor. **L** = The Government or an objective party runs risk management. **U** = It is not known who runs risk management (or if there is risk management). **NA** = There is no need for risk management, or risk can be managed effectively by any party.
32			Are the competition strategy, contracting approaches,	

Acquisition Systems Engineering (ASE) Baseline

- **The system description and characteristics, program definition, and acquisition approach that account for all aspects of a program relevant to cost and schedule**

- **Developed by a cross-functional program team**

- **Used to perform engineering trade-offs and estimates of all types in support of acquisition decisions**
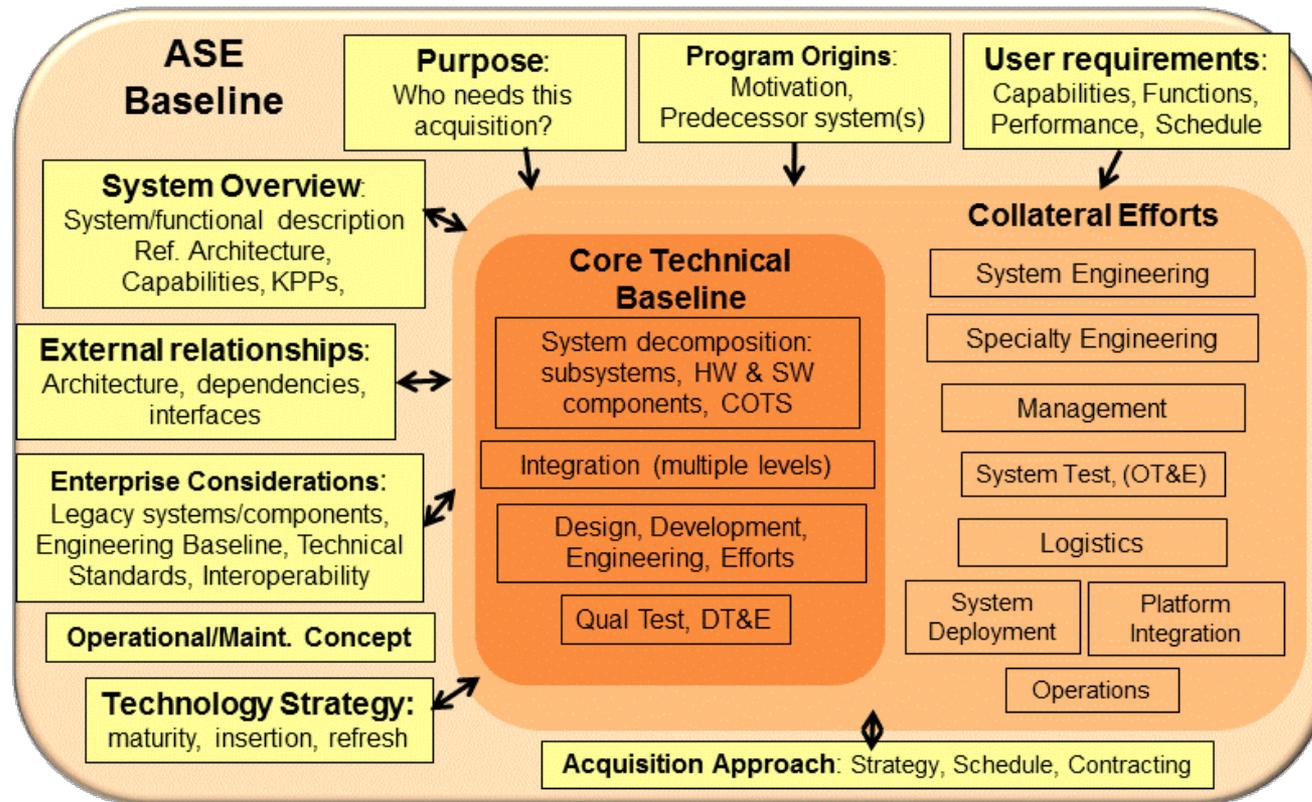
Being matured via the Affordability Engineering Framework (AEF) Capstone Project

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Relative Scope of the ASE Baseline

Program Baseline: entirety of program strategies, concepts, goals

ASE Baseline: Comprehensive Engineering Description. Includes CARD material with more detail.
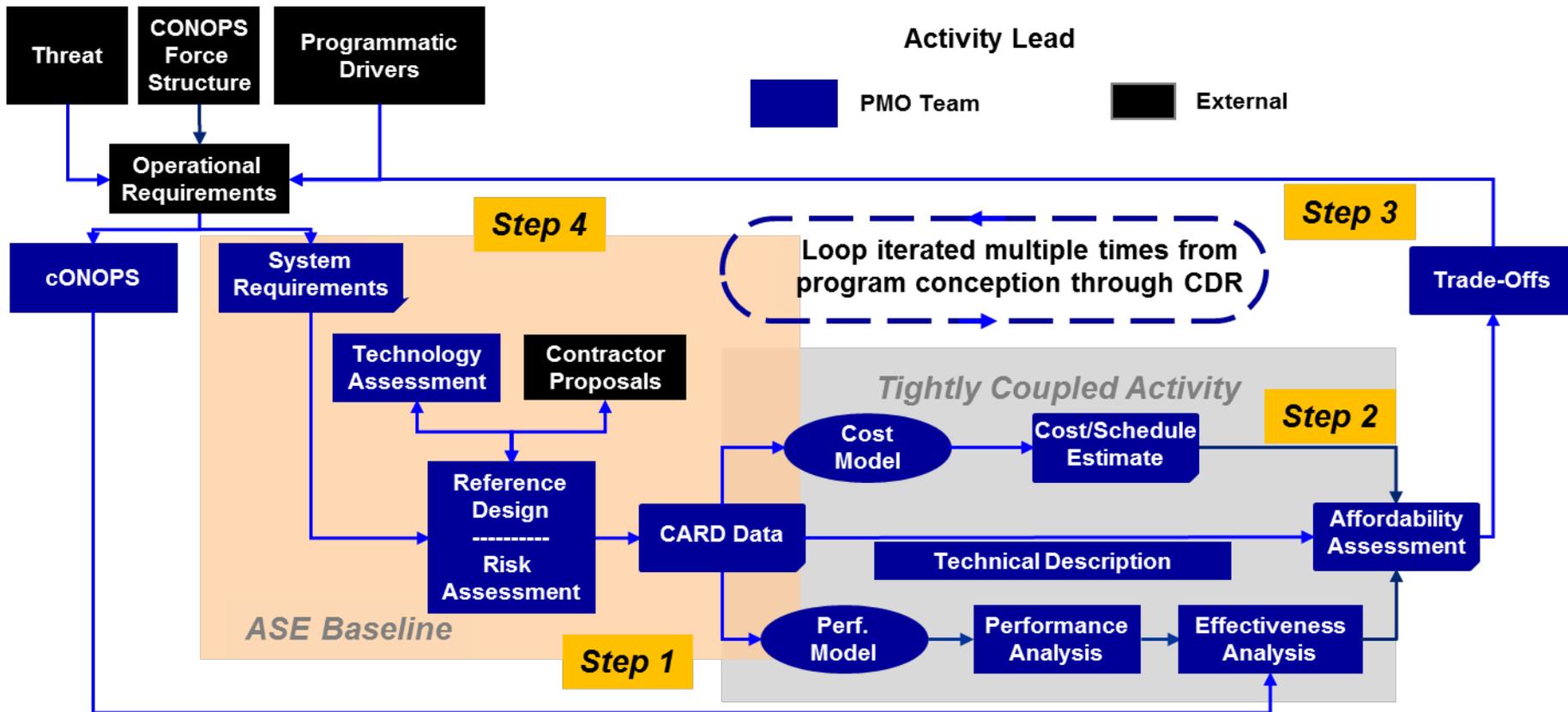
CARD: includes system attributes and references programmatic strategies

Core Technical Design and Physical Description

DoD 5000.4-M, 1992 DoD Instruction, with aspects written at a high level

Implementation activities, events, plans and technical details that influence the acquisition engineering effort and cost/schedule

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AEF Example

- **"Reference design" is key to coherency**
- **"Tightly coupled activity" permits rapid projection of performance, cost, schedule, and risk to support definition and refinement of system requirements**

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Lessons Learned from R-TOC Program

- Reduction in Total Ownership Cost (R-TOC) was a 1999 DoD initiative.

- 2008 IDA R-TOC Lessons Learned Memo

  – Involve command cost investment analysis personnel as part of the program IPT.

  – Accurate and timely data are essential to identify savings.

  – Try to understand the lifecycle implications when making decisions.

  – Large savings requires large investment.

R-TOC Pilot Lessons Learned/Best Practices

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