STRATEGY
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PERFORMANCE BASED SPECIFICATIONS: AN INVESTIGATION OF RISK MANAGEMENT OPTIONS

BY

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USAWC CLASS OF 1999

U.S. ARMY WAR COLLEGE, CARLISLE BARRACKS, PA 17013-5050

USAWC STRATEGY RESEARCH PROJECT

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An Investigation of Risk Management Options

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University of Texas at Austin

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ABSTRACT

AUTHOR: LTC J. Allen Maxwell

TITLE: **Performance Based Specifications: An Investigation of Risk Management Options**

FORMAT: Strategy Research Project

DATE: May 1999 Pages: 36 CLASSIFICATION: Unclassified

The use of Performance Based Specifications (PBS) is a major tenet of Acquisition Reform in the Department of Defense (DOD). Technical Data Packages (TDPs) of old are no longer affordable, thus requiring innovation in Defense procurements. From implementation in 1994, the use of PBS is mandatory for new procurements, including block and product improvements of legacy systems.

There is concern on the part of materiel developers (Program Managers and TRADOC System Managers) who feel a loss of control and a lessening of their ability to influence the acquisition process. While adapting to this new and still changing environment, materiel developers need tools now that can assist with this process.

This paper investigates two risk management options, consistent with the ARMY IMPLEMENTATION PLAN, BLUEPRINT FOR CHANGE: TOWARD A NATIONAL PRODUCTION BASE, that provide insight to the materiel developer, meet the user's requirements and yet do not impede the defense industry. The first technique discussed is the use of systems architecting tools to manage complex systems. The second technique combines activity-based costing with systems architecting to produce a technique called activity based risk management.

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ACKNOWLEDGEMENT

To the technical expertise and efforts of TASC, Inc. who were invaluable in completing this work. Specifically, the efforts of Mr. Will Nikonchuk, Dr. John Hall, and Mr. Dennis Loefelholz are greatly appreciated. I had the great pleasure and fortune to have the assistance of these people during my tenure as Product Manager, Longbow HELLFIRE. Their creativity and technical acumen were instrumental to the success of that program and assisting in the transition to Performance Based Specifications and contracting.

A sincere and heartfelt thanks to my family for this opportunity. Their sacrifices are more significant than they will ever know.

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INTRODUCTION

"The purpose of your research should be to learn something, not reinforce your prejudices." [1] This guidance could apply to many of us, as over the years, we performed research in school or investigated a problem that required analysis and correction.

Those words certainly apply with regards to this investigation of Acquisition Reform (AR), specifically, Performance Based Specifications (PBS). Until recently, my program management experience dealt with weapon system procurement that was conducted under strong government control. I learned that the government required ultimate control of the money, the process, and decisions inherent in procurement of materiel. Those days are gone.

As I left my last assignment, the project office was in the process of implementing many aspects of AR. None were more disconcerting than implementation of PBS. The project office was converting old contracts to the new format and laying the foundation for a multiyear, multi-million dollar contract using PBS.

AR is a given in today's acquisition environment and PBS is a major factor in implementing it. The choices are to resist the change, to embrace the reform as a panacea, or to seek a middle ground.

With caution, I find myself in the middle ground. I am concerned with the loss of control as a Product Manager (PM), since all of the responsibility still remains with that individual. Prudence says that we must get on board quickly, understand what AR is, and why it is necessary. Decreasing budgets and soldiers who deserve the absolute best equipment demand that we get it right. Optimism, tempered with reality, forces us to make it work and seek ways to improve it.

That is the basis for this research; an investigation of risk management options that are available to PMs in the current acquisition environment. The focus is on risk management techniques that can assist with AR, that can improve the process, but provide some acceptable level of insight and control to the new acquisition process.

BACKGROUND

To understand today's procurement environment and how to manage risk within that environment, it is absolutely critical to understand PBS. The intent of PBS is multifaceted; 1) It allows the government to provide industry with a concise and clear picture of what the service wants to procure. It is imperative to provide those requirements in such a fashion, that the options do not become limited, or even worse, the only solution is described in the requirement itself. 2) It allows the contractor to control the Technical Data Package (TDP), the floor plan or blueprints if you will, of the item or system being procured. Such freedom would allow industry to maneuver much more efficiently from both a manufacturing and administrative standpoint.

Manufacturing efficiency would be gained from timely substitution of piece parts without the required approval of the government in every stage as in prior days. Further, there would be no delay on the manufacturing floor since parts substitution would be under industry control, eliminating the precondition for government approval. The required administration to constantly update and distribute TDPs would be drastically reduced. 3) It allows the government to obtain goods and services at an affordable price. With government research and development as well as procurement dollars on the decline, it is mandatory that systems and services be reduced in price. If costs continue to escalate as they have for years, the services will procure fewer weapons. The number of weapons procured may be less, in some cases, than those necessary to meet mission requirements. A large part of the projected savings from acquisition reform would come from relief in military specifications in many cases. The idea being that the quality of parts from various suppliers would not change even though relief from military specifications was in effect. Industry would procure the same parts that are commonly used in many commercial applications and use the same part in military applications.

Realistically, there would be some difference in the parts. While many parts are currently built from the same materiel, under the same processes on the same manufacturing lines, military and commercial parts are not tested to the same degree. Military parts are tested much more for temperature extremes and durability than their commercial counterparts. For example, not many commercial parts are tested to –45° Celsius. The bottom line is that many commercial and military parts are identical in design and manufacture, but are tested differently.

It is in the testing to military standards that much of the exorbitant cost of military goods and services is incurred. The solution under PBS is to buy the same parts that are in commercial use, in large quantities, with the same reliability and quality, but without paying for much of the expensive testing.

In addition to the advantages of PBS, there were also disadvantages. "Tell us what you want, not how to build it" became the PBS anthem, sung by every contractor and small business. The government prefers, however, to specify nearly every environment and possible situation that a system might be used in, with subsequent development and qualification testing to verify system performance against these requirements. Without painfully detailed requirements and certification of the same, the government is accepting much greater risk. In the absence of very specific criteria, it would be difficult to cite, require evaluation and verification of pass/fail against a broad or non-existent standard.

Contractor control of the TDP was elegant in its simplicity, let the guy who's building the system control the blueprints. Who is better qualified than the guy building it anyway? If a part becomes unavailable through obsolescence or because the supplier exits the defense business, the contractor could easily substitute a similar part. Industry would avoid the expensive delays or stoppages in the production line and more easily meet the constant demands of the government to meet schedule. The problem for the government was a real lack of control. A unilateral action by industry for parts substitution became an issue quickly. Why should the contractor have the latitude to do so? After all, there may have been sufficient testing to satisfy industry, but is it enough to appease or convince the government that the part(s) was acceptable? Was enough testing done to adequately qualify the new supplier as reliable and capable of meeting government quality, quantity and delivery schedules?

The parts substitution/reduction of the testing issue was a key element in the projected cost reductions of materiel. Affordable systems with consistent quality were necessary, and very attractive to the government. As is true in some cases, the government got what we paid for. While the government was pleased with the cost savings, there seemed to be no end to parts substitution and reduction in testing and qualification. Can you blame industry though? In many cases they accepted fixed price contracts, requiring them to reduce costs whenever and wherever they could. With no hope of additional funding to cover cost growth, less expensive parts and less testing seemed a logical method to hold down expenses. Industry must make a profit to stay in business. They must appease industry analysts on Wall Street because negative news for projected earnings forecasts adversely impacts stock prices. Certainly, industry has a responsibility to the stockholders as well. With profit determined by the difference between the fixed price contract and the real cost of delivering the system or goods to the government, industry is incentivized to drive the delivery cost to the absolute lowest. Yes, industry has a reputation to protect. Their future business domestically and internationally depends on their reputation and past performance as well as the quality of their goods and services. Yes, many of those contractors served in the military, may have retired from the military, have sons and daughters or nieces and nephews in the military, but the fact remains that businesses are in the business of making money. The greater the difference between the cost of delivering a good or service and the contract price, the greater the profit margin.

In fairness to industry, they have delivered excellent materiel and systems to the government with slim profit margins. They cannot do so over an extended period of time or on numerous government contracts.

There is risk under PBS, that the good or service will perform no better than the requirement outlined in the PBS. Performance exceeding the requirement comes at a price to the contractor. It is a price for which the contractor will not be compensated and detracts from the bottom line. This design margin could be "part-substituted away" since there is no reward for exceeding the requirement. If a system or service proves to exceed the requirement in testing, there is no incentive for industry to leave it that way. From a business standpoint, it makes absolute sense for industry to procure cheaper parts to offset those parts that will inevitably cost more than expected. Finally, from a contractual standpoint, there is no way for the government to require industry to exceed the requirement even if technology and previous tests have proven that it is possible to do so. Dollars and cents will not allow industry to deliver materiel or services in excess of the requirement.

The reduction in testing, replaced by analysis and study, is a real risk to the government or any buyer of goods and services. Analysis, no matter how thorough, cannot postulate and resolve every outcome of the test. Neither does every test for that matter, but the combination of analysis and adequate testing makes the government feel more comfortable. There is something about empirical data and lots of it that makes us feel whole.

So we collectively find ourselves in this performance-based environment, forced by necessity, but unsure just the same. The contractor is pleased with his newfound engineering and design freedom, able to unleash the creative talents of the entire company. Industry is now able to substitute parts and materiels as commercial best practices and prudence allows. The contractor is confident of an innovative solution at an affordable cost to the government and at an acceptable profit percentage to corporate management and stockholders.

The government is also pleased with the affordability of systems and materiel and enticed by the prospect of future cost reductions. The government is pleased with the technology and solutions provided, but unsure of the level of risk we have taken on. We are uncomfortable with the loss of control knowing that the system will meet but not exceed our requirement.

The real issue is to address the gnawing feeling that PMs have. Maybe it is not so much the individual piece parts of materiel and systems, but the end result that should be our concern. As stated by Mr. Hoeper, "How do we mitigate the risks associated with performance based acquisition? Specifically, how does the Government guard against excessive contractor risk taking under this initiative?" [2]

Moving forward

We have pressed ahead with AR, transforming it to far more than an idea or concept. It is standard practice in new contracts, and is being implemented as old contracts are converted. It remains an evolving concept, a work in progress. This process to reengineer the DOD acquisition system has many initiatives, tenets and facets.

AR is being used for many DOD procurements. While reform initiatives apply to the procurement of all goods and services, it is of most interest in high-dollar, major end-item programs. The conversion from TDPs to PBS contracts has seen some growing pains, but it has seen successes as well.

Savings in real dollars, removed from the Program Objective Memorandum (POM) or distributed to other programs (i.e. Javelin, Longbow HELLFIRE), are not uncommon now. These savings have been taken from existing programs, some of which have been around for years. Other savings have been in the form of cost avoidances, programs that are only getting started but will cost far less than what they would have in the absence of AR.

In short, the DOD and the Department of the Army (DA) have come a long way in how we procure weapons systems as well as goods and services. The focus is on what we need, not telling industry what or how to meet the need. DOD's preference now is to use PBS first, then non-government standards (NGS) and if we must, Military Specifications (MIL SPECS/STDS) with the ultimate goal of fixing or replacing all other MIL SPECS/STDS over time. [3]

PBS defined

Even to the Program/Project/Product Mangers (PMs), TRADOC System Managers (TSMs) and industry representatives that operate in the acquisition environment, there are as varied definitions of what PBS is as the number polled. The most common response to defining PBS is accurate – PBS states what we want, not how to do it – but not complete. Omitted in the usual definition are the myriad interface requirements, especially when defining a system that is part of a larger entity, "a system of systems". An absolutely critical component is the criteria and means for compliance to the requirement.

The Army Implementation Plan (AIP) defines PBS as "...a compilation of all quantifiable requirements (e.g., form, fit, function, performance, and interfaces) and services. It states its requirements in terms of the required results with the criteria for verifying compliance, but without stating the methods for achieving the required results. It defines the functional requirements for the item/service, the environment in which it must operate, and interface and interchange characteristics."[4]

The focus then is on conveying to industry what good or service is needed complete with all requirements, interfaces and required performance. Yet implied, is that the requirement document must state in minimum form what is needed. This allows maximum creativity and a full range of possible solutions. Unfortunately though, a minimalist mentality while developing a PBS requirement document can degenerate to a page count, losing focus on the end product. The notion that a six-page PBS is orders of magnitude better than a forty-page PBS requirement document may exist and distorts the purpose of PBS. An accurate portrayal of the desired function and a thorough statement of need should be paramount in the process.

Implementation

The ARMY IMPLEMENTATION PLAN and the Report of the PROCESS ACTION TEAM ON MILITARY SPECIFICATIONS AND STANDARDS clearly provide the intent, rationale and roadmap for implementation of AR. The broad outline in these documents is as follows:

1) Performance Based Specifications
2) Eliminating Excessive Contract Requirements
3) Overhauling the Standards Process
4) *New Management Tools*

Oversight
Contractor Test and Inspection
Corporate Information Management for Acquisition
Automated Specifications and Standards Development Aids

Automated Acquisition Aids
Challenge Acquisition Requirements
Pollution Prevention

5) The Education Imperative

6) Instituting Cultural Change

7) General Acquisition Reform

Commercial Practices
Partnering
Activity Based Cost Management
Integrated Product Development (IPD)

The AIP is not a static document, rather one that is expected to change, incorporate new techniques and practices when practical. Within the area of New Management Tools/Oversight (paragraph 4 above), there is room for growth and improvement. Advances in risk management techniques and software systems must be included as the latest innovations to the evolving field of AR.

A relatively new engineering management tool of systems architecting is available. This technique has the potential to reduce government oversight in the management and procurement of weapon systems. It will instead provide much needed insight, participation between government and industry to the benefit of each, insight that is indispensable in the AR environment of PBS.

The focus of this research is to expand the current implementation plan for AR. Not to expand for expansion sake, but for completeness and inclusion of the latest innovations in AR.

Systems Architecting

History

Systems Architecting (SA) is not yet a common analysis tool in the acquisition environment. It is important therefore, to understand the discipline before applying the study to DOD procurements. As one would expect, systems architecting is a synthesis of disciplines. Systems are defined by Rechtin (Professor of Engineering at the University of Southern California) as "a collection of different things so related as to produce a result greater than what its parts separately could produce"[5] for the purposes of architecting. To complete the definition, architecting is both art and science where "architecting defines that form by matching, fitting, balancing and composing profound functions and forms until a practical result can be achieved."[6]

This discipline of systems architecting is relatively new, even though systems engineering degrees have been offered across the country for decades. The University of Arizona was the first to formally recognize the systems engineering discipline, offering masters and doctorates beginning in 1961. [7] Other universities and colleges followed.

Yet, Rechtin and Maier (Professor Maier is on the faculty of the University of Alabama in Huntsville) state that systems architecting degrees were first offered at the University of Southern California (USC) approximately 10 years ago. What began as an experimental program in 1989 became a formal masters degree in 1993.[8] It appears that the systems architecting revolution was a natural evolution of systems engineering, of the increasing complexity of tasks and systems, and the available computing power from the electronics industry.[9] With only six years as a recognized discipline, the full potential is not widely recognized or implemented in DOD and the services.

Application to DOD Standards

Delivery of the (AIP) in 1994 and the first systems architecting degrees from USC in 1993 are a fortunate coincidence. The former being a manifestation of the Packard Commission, the Goldwater-Nichols Act of 1986, and the Defense Acquisition Workforce Improvement Act of 1990. Acquisition Reform's genesis is in the commission and the legislation, but focused primarily on the personnel and structure issues. Establishing the much streamlined Program Executive Office (PEO), direct line access to decision makers and removing bureaucratic layers were key aspects of this reform. The AIP began the process on the hardware to alleviate the many military specifications and standards (MIL SPECS/STDS) that all agreed hampered suppliers throughout industry.

In the opinion of Rechtin and Maier, the relaxation of MIL SPECS/STDS could be anathema to the evolving discipline of systems architecting given that so much depends on quantifiable standards. "As useful as standards are, they are no substitute for bidding purposes, for qualifying a system for use, or for establishing responsibility or liability." [10] The problem associated with a lack of definable standards exists not only for the prime contractor, the joint venture or synthesizer of the total effort, but also for the suppliers and subcontractors as well. The flow down of requirements becomes increasingly difficult as the specification moves lower and lower to the second and third tier suppliers. It is much like the communication exercise that many of us have experienced during formal training. One person passes a message to a second, who in turn passes it on until the message reaches its intended person or destination. Many times the message at the end of the chain does not resemble the original message in any form. The possibility for such miscommunication exists in the absence of quantifiable military specifications.

It is my assertion however, that the effects may be mitigated by another aspect of Acquisition Reform. MIL SPECS/STDS are not being eliminated entirely, creating a void. Many are simply being replaced by commercial specifications, industry standards that are easily recognized by domestic and international companies. Commercial standards and single process initiatives are deemed to be an acceptable substitute for MIL SPECS/STDS. With a definable standard still available, the systems architecting discipline should continue to grow in importance and become a major analysis tool in the PBS environment. Much will depend on the willingness of project offices to use this new tool.

Application to DOD programs

DOD and industry need a universal capability to manage the many different types of systems ranging from aircraft and missiles to biochemical equipment. The required capability must be one that can be adapted to the specific needs of a program and adjusted to a specific program's status in development or procurement. PMs need a capability that can be licensed for use at a reasonable price, one that is available immediately, and one that can assist them in managing the risk inherent in today's complex systems.

Fortunately, such systems do exist today, only becoming available within the last five years. Their use is still limited and their applications are not well understood. The respective advantages and disadvantages of each will not be discussed here. A general discussion of two systems architecting tools, System Level Automation Tools for Engineers, (SLATE ™) [11] and Requirements Driven Development (RDD-100 ™), [12] will be discussed and serve as a basis for the capabilities that systems architecting tools bring to the table.

These systems use a total systems approach to verify performance against requirements, can track decisions made, and rapidly assess the impact of changes resulting from budget, power and weight changes to name just a few.[13] The capabilities are numerous in assessing environmental, personnel, and other critical issues associated with a program and its management.

These tools are applicable to new starts and can assist with requirements generation. It can further translate those requirements into system functions and allocate those functions. They are of great help in balancing the relative importance of cost, schedule, and performance at this early stage, long before the first piece of metal is ever bent. The tools are equally helpful for those programs approaching system disposal and dealing with environmental concerns and reuse issues. In fact, these tools can offer invaluable insight, regardless of the state of the program, and include, but are not limited to the following:[14]

- Proposals
- Analysis

- Planning
- Development
- Demonstration & Verification
- Manufacturing
- Re-engineering
- Maintenance
- Disposal

Requirements Verification

Of all the capabilities that systems architecting tools bring to the table, there is probably none as important as the requirement verification function. For one reason, there have been few new program starts in DOD in recent years, so most of the systems are in some rate of production, or completing demonstration/validation and about to enter production. There is a critical need throughout production and at this critical juncture to trace back to the requirements. Secondly, the systems that are on the table, regardless of their program status, have already or are in the process of converting to PBS. A TDP does exist, but the absence of a government controlled TDP during this transition makes requirements tracking and verification extremely important. Thirdly, many of the systems that are fielded today will be there for the next thirty years. Almost all of them will be enhanced, product improved, modernized through spares, or undergo a service life extension program. These options allow DOD and the services the opportunity to upgrade systems without the greater expense of new starts. Inherent in all of these options is the absolute necessity to track the current system requirements as well as the new. It is imperative to ensure that the systems continue to meet all requirements and that substantive proof exists for the contractor and PM to deliver the systems to the field.

Current processes to verify and track requirements are not effective in a PBS environment. There is information to manage, but it comes to the project office from industry in the form of unique test events, slides and presentations at program reviews, and formal/informal engineering change proposals. The real information for understanding is lost sometimes in the reams of data. The effects of hardware or software changes upstream and downstream of the modifications are not readily known.

SA provides at least three major benefits with respect to requirements of complex systems: 1) It establishes a means of control within the PBS for good verification methods and management, 2) It assists with requirements definition and tracking as part of verification management, and 3) It automatically links requirements verification to verification test/activities. This provides the necessary insight or information sharing to sufficiently evaluate the end product and ultimately execute the PBS contract.

Parts and components change frequently in systems that are in production for numerous reasons. The suppliers of those parts leave the defense business for a booming commercial business or just decide that they do not want to do business with the government any longer. Diminishing military suppliers mandate substitute parts resulting in an unknown impact at the systems level. Parts substitution can lead to concerns over design control, performance uncertainties in design margin drift, and the appropriateness of the verification methods to measure performance.

Figure 1 depicts in greater detail the activities on the respective sides of the government and industry while the PBS requirements are developed and incorporated into a system. Little coordination appears to be going on, with government and industry working separately until a formal verification event at or near the end of the process. In reality, the PBS requirement is being developed by consensus of the materiel developer, the user, and industry. Upon completion of the PBS, industry develops the design specifications, which are translated to a product baseline. Within the system, the contractor can use any systems architecting tool to achieve optimal design. The collaboration effort continues with proper licensing agreements, at both government and industry. The systems tool provides data with feedback allowing a consistent approach with the government's risk management program. There is also a clear link and traceability from development of the requirements in the PBS and the corresponding verification event. The final coordination link is the crosswalk between the government and industry to verification purposes.

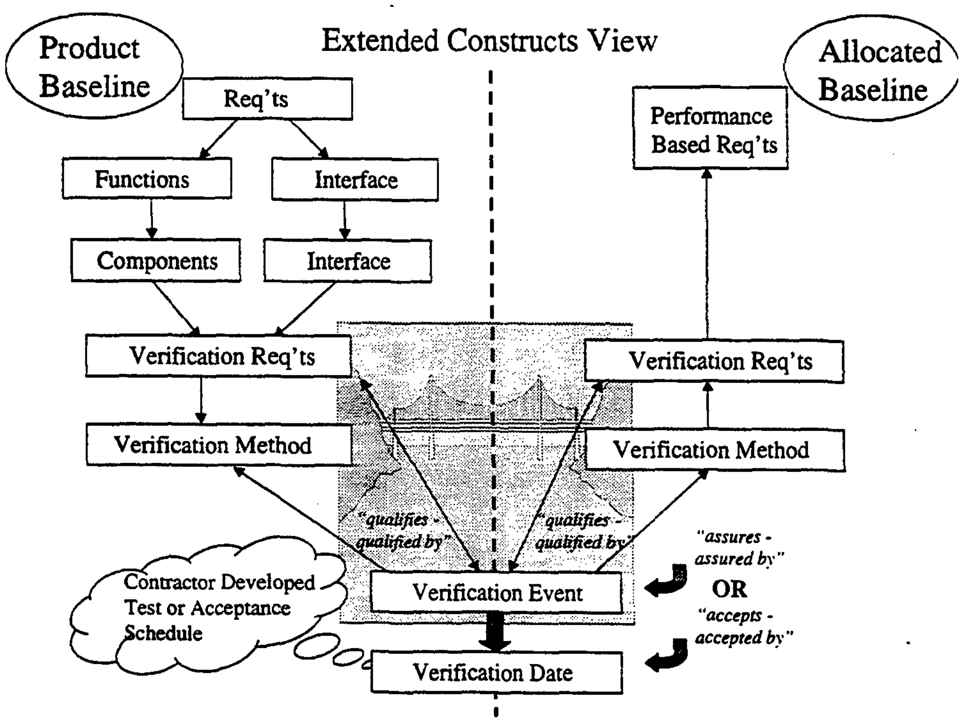

Figure 1[15]

Engineering Change Proposals (ECP)

In addition to parts changes, innovations continue to make the product better, more reliable, and cheaper. The result in either case is an ECP that will change the system as we know it. This change to the baseline system is always at least intended to maintain the sub-component and systems level performance. To verify the compounding effect of multiple ECPs is truly beyond even the most talented systems engineers when dealing with complex systems.

This can be mitigated as shown in Figure 2. Preliminary data from multiple sources can be used initially to evaluate various aspects of an ECP. This preliminary analysis is incomplete unless the requirements can be verified via an appropriate test plan or activity. The system assessment is wanting. Within the system architecting model, all the performance (form, fit, and function) and interface issues can be evaluated. With the assessment complete, the industry/government team that forms the Integrated Product Team (IPT) can make an informed decision.

It is critical too, that the affects of hardware and software changes upstream and downstream of a specific component be evaluated. While the system level test is paramount, ensuring interface match ups as well as form, fit, and function, will go a long way to ensure stable performance at the system level.

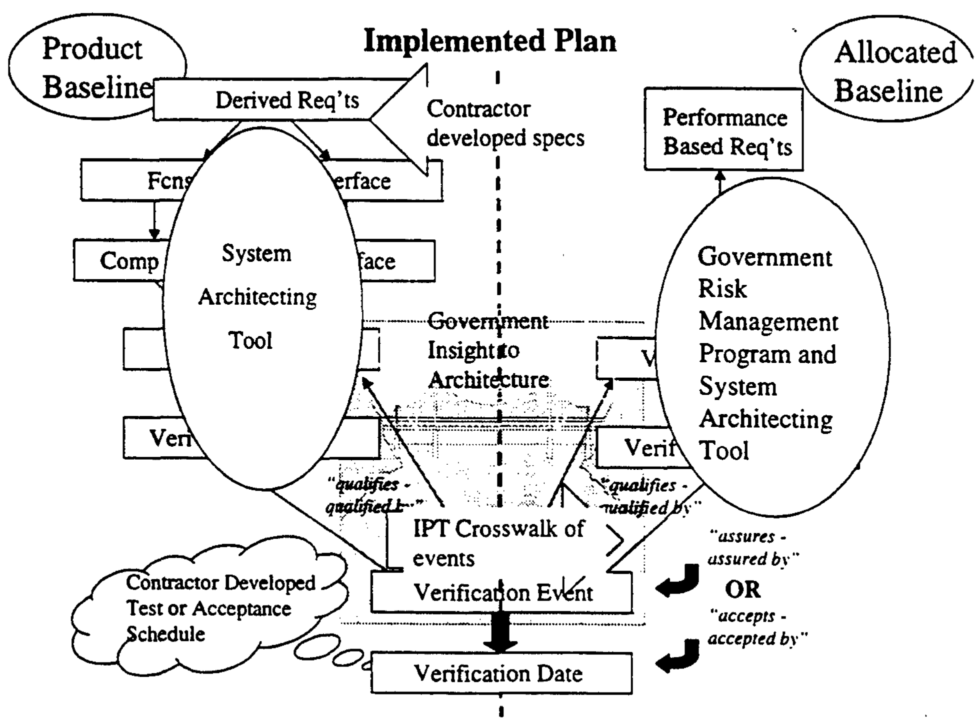

Figure 2 [16]

The key to success of the program is not directly evident. Every member of the project office is responsible for building and maintaining their individual elements of the system architecture and the corresponding changes. The activity of each element is recorded within the systems architecture and can easily be viewed by and communicated to others. What is evident is the continuous process of monitoring activity and executing the necessary audits to ensure verification. In the end, the PBS process can be monitored with an effective requirements and verification process. The new requirement specification method is consistent with acquisition reform.

The Army Modeling and Simulation Office (AMSO) Connection

When Systems Architectures are mentioned, immediately thoughts go to AMSO. The proliferation of software in weapons systems and the desire to effectively use available resources calls for standardization and centralization at some level. Adding to the sheer numbers of software intensive systems and the proliferation of simulations is the complexity of the interaction between systems. No longer are weapons independent actors, but a system of systems passing information to and from each other

The AMSO deals in the following arenas where systems are affected:[17]

- Acquire
- Architecture
- Attrition
- Command, Control, Communication, and Computer Integration (C4I)
- Command Decision Modeling
- Communication Systems
- Cost Representation
- Data

- Functional Description of Battlespace
- Logistics
- Mobilization/Demobilization
- Move
- Object Management
- Semi-Automated Forces
- Terrain
- Visualization
- Verification, Validation, and Activation (VV&A)

Among their missions as the focal point for all modeling and simulation matters, the office ensures integration across three domains within the Army:[18]

- Advanced Concepts and Requirements (ACR)
- Research, Development, and Acquisition (RDA)
- Training, Exercises and Military Operations (TEMO)

As broad as the responsibilities of AMSO are, the use of system architecting tools does not fall under the purview of AMSO. The tools described, as well as many others, are commercially available and are intended for use in program management. Performance characteristics of systems using these tools are limited to characteristics previously described; form, fit, and function of components. Performance is intended to be the sense of capturing the effects of changes throughout the weapon system if hardware or software changes are made. There is no attempt to grade performance parameters such as Probability of Kill (Pk), loss ratios, or the effects of such key parameters in adverse conditions. Finally, there is no representation of system architecting tools to evaluate effectiveness or force-on-force type assessment.

PMs should be able to acquire and use system architecting tools to assist in the management of the program. SA should be simply a new tool in the PMs toolbox.

Activity Based Costing

A second key element of AR and described in the Blue Print for Change is activity based costing (ABC). This new procedure provides a better way of capturing costs initially and then properly allocating those costs to various activities. This understanding allows PMs to understand what activities are really costing them in terms of their limited resources.

As stated in the AIP, the acquisition community should "continue to encourage and assist contractors to use activity based costing in circumstances where the method could improve cost allocations, bidding and cost-reimbursements."[19] While these functions are important, they are limited in scope and utility. Such functions are limited to the front end of procurements, very early in the life cycle. The real power of ABC lies however, in application throughout the life cycle. With some modification, ABC can be used in all phases of acquisition and procurement.

In general, ABC is an evolving discipline but can improve on the shortcomings of other accounting procedures. ABC follows a rigorous five step procedure:

1) analyze activities
2) gather costs
3) trace costs to the activities
4) establish output measures

5) analyze costs

and by doing so arrives at the cost per unit of output.[20]

$$\text{Cost Per Output Unit} = \frac{\text{Total Activity Cost}}{\text{Total Units of Output}}$$

ABC attempts to establish a relationship between the cost of activities and their respective outputs. Previous accounting methods failed not only to do this "...but fails to meet the full requirement for management information" [21]that decision makers require.

Organizational Accounting

"This system was created to provide management with information on the costs or organizational elements, but was never intended to define the output costs either at the element or organizational level. "[22] This system simply allocated costs to functions within the organization, (program management, test, engineering, etc.) and usually only captured direct labor costs or salaries within each function. Infrastructure and overhead costs were captured at the highest level and were not directly allocated to specific functions or activities.

Budgetary Accounting

There are two major concerns in any DOD activity. The first is that unforeseen circumstances will require more money than you have in your budget. The second is that the agency will not be able to spend all of the money budgeted to it. The second instance is rarely the case these days given recent budgets, but obligations and disbursements are closely tracked. The goal is to obligate the money quickly and ensure full use of all allocated resources. "The major objective [of budgetary accounting] was to fully use the resources assigned rather than enhance productivity or to reduce expenses, because any attempt to conserve resources led to a reduction in the future budget resource level."[23] It is clear from this line of thinking, that the cost of individual activities was not an issue unless overspending of one caused the organization as a whole to overspend. If a single organization overspent, using up the excess money from another organization in the process, everything was fine. The books at the organization level must remain within budget.

Traditional Cost Accounting

"Traditional cost accounting has been used for over a hundred years and provided a reasonable look at the costs associated with the production of goods or services and processes."[24] The major factors were accounted for; direct labor, direct materiel costs, and overhead. The DOD is particularly interested in profit as well because of its significance in bids and proposals as well as cost-reimbursable contracts.[25]

Traditional cost accounting information was once useful. Only recently though, it has been learned that traditional cost accounting may provide information that can lead to incorrect management decisions. The process of capturing and allocating costs seems basic. Performing ABC correctly an lead to interesting results, especially when compared to earlier cost accounting methods. A comparison of ABC accounting to traditional accounting is provided at Figure 3.

ABC Production Example

1. Operations Output & Pricing

	Production	Avg Mkt Price	Your Cost
Output A	200 Units	$125	$110
Output B	800 Units	$18	$20

Output A is very competitive and carrying the operation

Output B is costing too much and should be eliminated from production

2. Additional Information

Direct Costs

Output A $100 /unit Output B $10/unit

Overhead Costs: Purchasing Dept

Annual workload= 10,000 purchase orders with Annual cost = $10,000

Purchase Orders required per unit for A = 30

Purchase Orders required per unit for B = 5

3. Cost Distribution Table

Traditional Cost Accounting

Total Output /Total Overhead = Amount per Unit of Output

$10,000/1000 = $10

Activity Based Accounting

Activity Cost/ Activity Workload = Amount per Unit of Activity

$10,000/10,000 = $1

Activity Units * Amount per Unit = Total Output Cost per Unit of Activity

Output A: 30 * $1 = $30

Output B: 5 * $1= $5

4. Total Cost per Unit Output

Traditional Cost

	Direct Cost +	Overhead	= Total Cost
Output A	$100 +	$10	= $110
Output B	$10 +	$10	= $20

Activity Based Cost

	Direct Cost +	Overhead	= Total Cost
Output A	$100 +	$30	= $130
Output B	$10 +	$5	= $15

Costs are traced to the amount of the activity actually used, rather than as a straight distribution based on output allocation

Figure 3[26]

The potential pitfalls of traditional cost accounting methods are shown in a basic production case. In phase 1, the number of units of an item produced, the cost to produce them, and what they bring on the market is known. It appears that item A is profitable to the company, yielding fifteen dollars in profit per item. Item B appears to be a loser, costing two dollars more to produce than it can be sold for.

In phase 2, direct costs (labor and/or materiel), overhead, and the separate purchase orders for each item are identified. This additional information allows us to take a more in depth look at what each product is really costing.

Phase 3 assigns those costs using two accounting methods, traditional and activity based. Traditional accounting divides the total overhead costs ($10,000) by the output (800 + 200 or 1000 units) to derive the cost per output unit. In this case it is $10. ABC identifies the cost per activity by dividing the total overhead costs ($10,000) by the number of activities, which are 10,000. The cost per unit output then is $1. By correctly allocating overhead to the activities, item A requires 30 activities or $30 of overhead while item B requires only 5 activities or $5 of overhead per item.

In phase 4, we can now identify the total cost per unit of output. Using traditional accounting methods, the direct and overhead costs are added to give the original data from phase 1. Using ABC, we find a much different answer. The real cost per output of item A is discovered to be $130, not $110 as calculated in traditional accounting. Further, it is discovered that item B only costs $15 per output, not the $20 as calculated using traditional accounting methods.

The activity based accounting method provides the real answer. Item B is really making $3 per unit on average since it costs $15 to produce and sells for $18. The big surprise is that item A is losing $5 per unit on average. Item A costs $130 per output but only sells for $125.

Using just traditional accounting, we would have made a major mistake if we had eliminated item B from production. ABC accounting provided a much different result by properly allocating costs to the activities of each item. In other words, costs are traced directly to the amount of activity each item is using.

ABC is an example of DOD further adopting commercial practices, a narrowing of the gap in the way DOD and commercial businesses operate. This management technique was developed in the private sector to capture all costs associated with a process and correctly allocate those costs. By doing so, the cost of a process or function could be identified and a determination could be made to see if the function should be modified. The technique can assist in identifying those activities that cost more in resources, than the value of the output is worth. In other words, ABC can assist in identifying these activities that do not add value to the decision making process and management of the program.

ABC is a necessary outgrowth of previous accounting methods. It is an attempt to capture costs better, but more importantly to allocate them correctly. By doing so, activities that are expensive relative to the value of their input can be improved or eliminated.

As shown in the previous example, ABC provides new insight into organizations that have a quantifiable output; a physical product or entity. Additionally, processes where dollars per transaction can be identified benefit by this.

Unfortunately, program management and the procurement of weapons systems will benefit little from a pure application of ABC. It is extremely difficult to measure the value of a programmatic decision, even though such activities require resources in terms of salaries, office space, and materiels. Further, engineering and test management (stockpile reliability, quality assurance, and lot acceptance) are vital program management functions that use resources. Fortunately, there is something that can help. With ABC as a building block, recent efforts have yielded a new methodology to combine ABC with activity based management and produce Activity Based Risk Management (ABRM).

Activity Based Risk Management

The methodology and approach used in ABC has excellent application to Risk Management. There are many types of risk, but for the purposes of this study, the focus will be on quality assurance and acceptance activities.

Managing risk inherent in the product acceptance phase meets all the criteria desired in the AIP:

1) It uses the ABC methodology, slightly modified, but throughout the acquisition life cycle. Initial implementation in the AIP called for extended use in bidding and proposals as well as cost comparisons. With enhancement, the technique can be used late in the program cycle for quality assurance and for acceptance of production hardware.
2) Quality assurance/acceptance is a defined activity that uses resources; money in terms of salaries, personnel, facilities and time. Using ABC can

easily allocate the resources consumed in the process. The quality assurance event can provide information that can be used to evaluate and assist with program management decisions.

ABRM can be linked to specific test activities through Systems Architecting as described in the first part of this paper. The verification activities previously described are the very events highlighted by systems architecting. Those events are required to verify test performance and traceability from requirements in the performance based specification.

The activity traces directly to requirements that are tracked and managed within the systems architecture. It ensures that requirements are verified and the means of verification are captured, regardless of whether the changes are driven by ECPs. The activities verify cost and performance and provide essential test data for managing risk and decision making.

As previously discussed, the systems architecture is an integral part of the project office's risk management plan. The data provided by the various activities can now be used a means to measure and manage the risk inherent in complex systems.

The CAM-I Cross

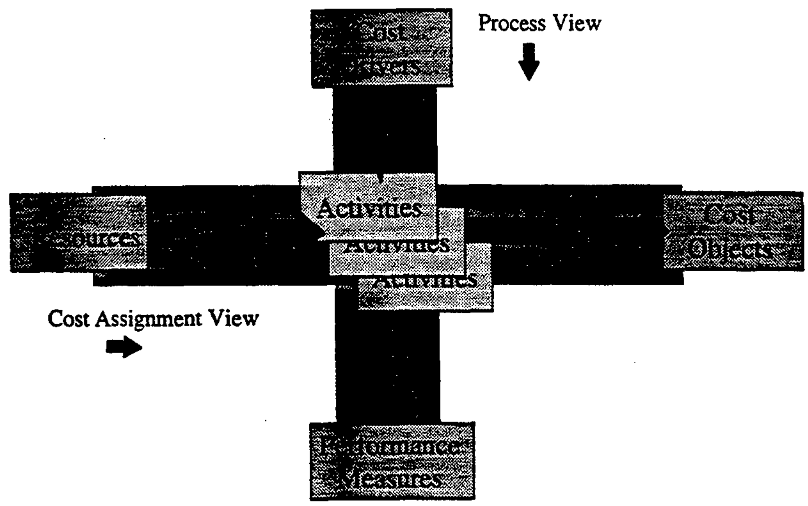

Figure 4 [27]

As shown in Figure 4, the Computer Aided Manufacturing International (CAM-I) consortium describes the relationships and identifies the structure of ABC. The linkage between the numerous activities, the resources to execute them and their relationship to output is captured. With limited resources, the PM can determine the cost of various activities relative to their importance. This information will assist in determining whether required information will be obtained through test activities, less expensive inspections, analysis only or a combination of such activities.

It must be understood that any test activity, especially qualification and acceptance testing, that every event cannot be tested. All the parameters to be checked must be recognized and their criticality to the system must be determined. The testing must be designed to check as many parameters as the budget will allow. Knowing the cost of each activity via ABC and identifying all critical parameters through proper test design is the essence of ABRM. PMs can gain the critical information they need within the resources allocated and manage the risk in their program.

Conclusion

SA tools offer the possibility to do much to assist in AR. Their use however, does not guarantee program success. Like any other tool, the user must understand it and use it properly. Fully implemented system architecting tools offer numerous benefits. They allow for a complete look at a system from requirements generation and tracking to functional allocation of those requirements. They allow a crosswalk between the government and industry and the requirements and verification activities.

Inherent to SA tools are integrated systems models such as behavior models for performance, Process Models for manufacturing and supplier issues, Cost Models for components, and Support Models for monitoring warranties, stock pile reliability programs, logistics, etc. Finally system architecting allows for documentation generation and bookkeeping of verification activities.

Systems architecting also offers the capability to assist with risk management. The activities that are identified, tracked and verified with regard to performance can be costed using activity-based methods. The combination of systems architecting and activity based costing can greatly assist PMs in better utilizing their limited resources. Ideally, PMs will be able to better address the demanding issues of program management within constrained budgets.

In summation, system architecting provides a foundation for shared knowledge, communication, and insight. The evolving and unique environment of acquisition reform calls for new and effective management approaches. System architecting provides the capability to manage in a PBS environment, yielding insight to complex systems that government and industry absolutely require.

ENDNOTES

[1] Elspeth Rostow, Professor of Public Policy, Lyndon B. Johnson School of Public Policy, University of Texas, Austin, 7 April 1999, while reminding her students that research papers for her class were due soon and what the purpose of that research should be.

[2] Possible research topics for Senior Service College students from the Office of the Assistant Secretary of the Army (ASARDA), The Honorable Paul Hoeper, provided to U.S. Army War College Fellows, Austin, TX, September 1999.

[3] ARMY IMPLEMENTATION PLAN, Implementing the Report of the DOD Process Action Team on Military Specifications and Standards, BLUEPRINT FOR CHANGE: TOWARD A NATIONAL PRODUCTION BASE, 23 November 1994, page 4.

[4] Ibid, page 10.

[5] Institute of Electrical and Electronics Engineers (IEEE) Spectrum, October 1992, the art of systems architecting, by Eberhardt Rechtin, page 66.

[6] Ibid, page 66.

[7] The Art of Systems Architecting, Eberhardt Rechtin and Mark W. Maier, 1997 by CRC press, page 221.

[8] Ibid, page 222.

[9] IEEE Spectrum, October 1992, the art of systems architecting, by Eberhardt Rechtin, page 66.

[10] The Art of Systems Architecting, Eberhardt Rechtin and Mark W. Maier, 1997 by CRC Press, page 221.

[11] http://www.tdtech.com/papers/history.html, SLATE History and Theory. SLATE is a registered trademark of Texas Instruments. It is a systems level tool for simulating complex systems.

[12] The Application of a Tool like RDD-100 to Accommodate Traceability from Requirements to Test Results, by Byron Smith. RDD-100 is a registered trademark of Ascent Logic Corporation. This tool supports modeling and simulation, and system requirements.

[13] http://www.tdtech.com/sl8demo/DODRFRM.html

[14] http://www.tdtech.com/papers/apslate.html, Applying SLATE in Different Environments.

[15] "Getting Insight", A Systems Architecture Approach, Will Nikonchuk, 27 October 1998, TASC, Inc., page 9.

[16] Ibid, page 10.

[17] US Army Model and Simulation Management, Colonel Steve Collier, Army Model and Simulation Office, presented to the US Army War College Fellows at the University of Texas, October 1998, page 4.

[18] Ibid, page 3.

[19] Report of the PROCESS ACTION TEAM ON MILITARY SPECIFICATIONS AND STANDARDS, BLUEPRINT FOR CHANGE, April 1994, page 183.

[20] http://www.dtic.mil/c3/bprcd/0201f18.gif, Figure 18.

[21] http://www.dtic.mil/c3i/bprcd/020lcl.htm, The Electronic College of Process Innovation, ABC Guidebook.

[22] Ibid, page 2

[23] Ibid, page 2.

[24] Ibid, page 2.

[25] Report of the PROCESS ACTION TEAM ON MILITARY SPECIFICATIONS AND STANDARDS, BLUEPRINT FOR CHANGE, April 1994, page 183.

[26] Activity Based Risk Management, Will Nikonchuk, TASC, Inc, November 1998, page 4..

[27] Ibid, page 5.

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REMARKS

Attached "Strategy Research Project" Paper SUPERSEDES previous SRP sent to DTIC 8/11/99.

Any questions please contact Melody Baker, at (717)245-4317.

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