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Assessing Cost-Reduction Initiatives in a Changing Defense Acquisition Environment A Handbook

Karen W. Tyson, Project Leader
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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Director, Program Analysis and Evaluation under a task entitled "Cost Estimation for Streamlined Manufacturing Environment." This publication describes cost-reduction initiatives that are being undertaken by contractors and the government and suggests methods for analyzing their cost implications.

This work was reviewed within IDA by Karen J. Richter and outside IDA by Alexander Flax and William E. Thurman.

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I. OVERVIEW

A. PURPOSE

The Department of Defense (DoD) and the defense industry have responded to constrained funding for major weapon systems[1] by developing and implementing cost-reduction initiatives. These initiatives include a variety of techniques, some adapted from the private sector and facilitated by acquisition reform, others unique to DoD. Some acquisition programs might be unaffordable without these initiatives.

The historical cost and schedule data and models typically used to estimate costs and schedules may not include the effects of the new constrained budget environment. Moreover, some of the initiatives are so new that even pioneering programs are not yet far enough along to show actual cost and schedule savings, only projections.

This handbook contains a taxonomy that describes the major government and contractor initiatives being implemented or considered and presents an approach for assessing them. It is intended to assist cost, budget, program, contracting, and policy analysts to predict the cost savings likely to result from implementation of cost-reduction initiatives, assess the realism of a bidder's proposal that includes such initiatives, determine whether claims of cost savings may be no different from savings achieved due to the classic learning relationship in manufacturing, or decide whether the government should invest in a particular initiative.

While many of the initiatives are new, some of them have historical antecedents or have been practiced in the commercial world before government contractors adopted them. Evidence from these practices can be helpful in assessing the usefulness of the initiatives. The handbook provides a historical perspective on these early implementations and their results. The taxonomic structure includes generally accepted definitions, hypothesized cost effects, benefits, and caveats. In many cases, more than one initiative is used in a given program. Therefore, the nature and potential impact of interdependencies

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1 This handbook does not consider cost-reduction initiatives for procurement of smaller items where there has already been an impressive record of cost reduction through adoption of commercial practices.

among initiatives is also highlighted. Finally, this handbook provides a method for assessing the realism of savings claims due to such initiatives based on two models, a budget model and an investment model.

B. WHY COST-REDUCTION INITIATIVES?

In some sense, cost-reduction initiatives are nothing new. Throughout the history of the DoD, new acquisition policies have been proposed. From prototyping in the Truman era to the Carlucci initiatives under Reagan and on to the current era, each "new way" was touted as the path to better weapon systems for less money.

Despite continuing efforts to reduce costs, acquisition programs historically have had varying degrees of success in developing and producing weapon systems on time and within budget. Several studies that analyzed a large number of acquisition programs from a broad historical perspective found little indication that cost and schedule outcomes in general are getting substantially better or worse over time.[2]

While there has been little improvement on average, the wide variability of historical outcomes does provide the opportunity to ask: What distinguishes the more successful programs (in terms of adhering to cost goals) from the less successful ones? Several distinguishing characteristics can be noted. Equipment types with the lowest cost growth were ships, and tactical munitions and vehicles had the highest cost growth. For most weapon types, systems that were modifications of a predecessor system had lower cost growth, because they tended to be less risky technically. Prototyping, multi-year procurement, and development contract incentives appeared to help to reduce cost growth.[3]

According to a 1994 analysis of missile programs:

> Keys to preventing overall cost growth are correctly estimating the degree of technical difficulty in the programs and maintaining the planned production schedule. Programs that employed a high degree of concurrency, that had to be dual-sourced for technical reasons or that were dual-sourced at less than full rate, had high cost growth. In one case, the

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2 See J. A. Drezner, J. M. Jervaise, R. W. Hess, P.G. Hough, and D. Norton, "An Analysis of Weapon System Cost Growth," RAND MR-291-AF, The RAND Corporation, 1993, and Karen W. Tyson, Neang I. Om, D. Calvin Gogerty, J. Richard Nelson, and Daniel M. Utech, "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs," Paper P-2722, 2 volumes, Institute for Defense Analyses, November 1992.

3 Tyson et al., op. cit.

threat of competition appeared to reduce costs.[4]

Another way of querying the historical data is to consider what factors affect cost growth. A study that took this approach concluded:

> We found few strong relationships that would help explain the cost growth outcomes we observed. While program length, program size, maturity, and modification versus new developments are significantly correlated with cost growth, no single factor explains a large portion of the observed variance in cost growth outcomes....Hence, the problem of cost growth does not have a "silver bullet" policy response.[5]

The current set of initiatives originated largely from two major events. The first was the growth of global competition. Strong international companies with high-quality products forced a variety of US industries to change their manufacturing and management practices radically. Many defense industry initiatives are being patterned on these practices, sometimes referred to collectively as "new ways of doing business." Many of these practices began in the 1970s in the automobile, electronics, and copier industries. The second event, the breakup of the Soviet Union and consequent easing of world tensions, has forced DoD to consider new ways of relating to industry and forced the defense industry to consider new ways of doing business.

1. Crisis in US Industry: The Global Economy

During the late 1970s and early 1980s, global competitors rose to challenge US industry. American consumers enthusiastically purchased Japanese automobiles, and US automobile manufacturers, particularly Ford and Chrysler, found themselves in economic difficulties.

While cost reduction is the focus of this handbook, it is important to note that the problems US industry faced were broader than that. In the case of automobiles, American consumers perceived Japanese cars as being of higher quality and better design than US products. To remedy the situation, automobile manufacturers had to recognize the triangular relationship of product quality, product cost, and customer satisfaction. The relationship between quality and cost, as propounded by Deming, was difficult for many

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4 Karen W. Tyson, Bruce R. Harmon, and Daniel M. Utech, "Understanding Cost and Schedule Growth in Acquisition Programs," Paper P-2967, Institute for Defense Analyses, July 1994.

5 Drezner et al., op. cit.

traditional managers to accept.[6] However, the idea that reducing rework and scrap in production both improves quality and reduces cost eventually was widely accepted in the US. Automobile manufacturers thus responded to the Japanese challenge with vigorous business process and manufacturing redesign.[7]

During the late 1970s and early 1980s, Xerox lost 50 percent of its market share worldwide, much of it to Japanese competitors. In response, Xerox implemented a continuous improvement process to find ways to develop, produce, and market its products better and cheaper. Benchmarking was an important part of this process. The notion of “best practices” suggested that a company search for another company that best did a troublesome part of the business, and learn from that company. For example, Xerox used L.L. Bean’s order fulfillment process as a model to improve its own. Alhough Xerox and L.L. Bean have vastly different products, the order fulfillment process was common to both.[8] By 1985, Xerox had cut development cost, development schedule, and manufacturing costs in half and had begun to regain market share.[9]

2. Crisis in Defense Acquisition: Declining Budgets

Throughout the Cold War, the United States acquired technically sophisticated weapon systems designed to meet the threat posed by the Soviet Union and its allies. This strategy translated into ambitious programs to develop and field advanced weapons, incorporating path-breaking technologies. Regardless of the desire to contain weapon costs, the threat, as studied and forecast by the intelligence community and the military services, dictated high performance levels. While cost was an important consideration in weapon programs, performance was the first priority in DoD’s weapon development strategy, followed by schedule. In this “business as usual” (BAU) approach, the requirement drove performance, schedule, technology, and cost, with only marginal changes in the requirement possible. The requirement also drove quantity. If funds were

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6 W. Edwards Deming is noted for his work in Japan, training managers in quality management. He is the author of *Out of the Crisis* (Cambridge, MA: MIT/CAES, 1986) and *The New Economics* (Cambridge, MA: MIT/CAES, 1994).

7 See James P. Womack, Daniel T. Jones, and Daniel Roos, *The Machine That Changed the World: The Story of Lean Production*, Harper Collins, 1991.

8 US General Accounting Office, *Business Process Reengineering Assessment Guide*, GPO: Washington DC, 1995.

9 Gary Jacobson and John Hillkirk, *Xerox: American Samurai*, Collier Books: New York, 1986.

limited and the program developed problems, typically, quantity was reduced to fit into the budget.

Until recent acquisition reform measures, defense weapon systems have been produced in a tightly regulated environment with a carefully controlled acquisition process. The DoD customer was actively involved at all stages of the process. The contractor developed system components uniquely for each weapon system. Many defense observers have concluded that the regulatory and administrative process added costs. While some regulations and administrative procedures were necessary to protect the government's interests, others were believed to add unnecessarily to costs. Like DoD, commercial industry faced a crisis involving too many people in the organization, cumbersome processes not focused on the customer, and resistance to change. Industry faced myriad regulations and specifications that made some commercial companies reluctant to deal with DoD.

The end of the Cold War brought smaller acquisition development and production budgets—the procurement budget declined more than 60 percent in real terms from 1985 to 1994. This forced DoD to explore new strategies for containing costs.

3. A New DoD Culture: Facilitator of Initiatives

Acquisition reform is an overarching DoD initiative to eliminate burdensome military specifications, standards, acquisition regulations, and acquisition policies the government imposes upon the defense industry. The DoD's acquisition reform vision is that "DoD will be recognized as the World's smartest, most efficient, and most responsive buyer of best-value goods and services that meet our warfighters' needs from a globally competitive national industrial base."[10] This will be achieved by:

- ***Adapting the best practices of world-class customers and suppliers.*** This involves facilitating adaptation of the best practices of commercial industry to the defense acquisition process.
- ***Continuously improving the acquisition process to ensure it remains flexible, agile, and, to the maximum extent possible, based on best practices.*** This involves streamlining the process and ensuring that DoD organizations are value-added team participants, not inspectors.
- ***Providing incentives for acquisition personnel to innovate and manage risk***

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10 *The Defense Acquisition Revolution, DoD's AR Vision* [Online], (December 19, 1997), Available: http://www.acq.osd.mil/ar/mission.htm [December 29, 1997].

rather than avoid it. This involves tailoring acquisition policies and processes to the type of acquisition and providing alternative acceptable approaches rather than mandatory policies.

- ***Taking maximum advantage of emerging technologies that enable business process reengineering and enterprise integration.***[11]

In October 1994, the Federal Acquisition Streamlining Act (FASA) became law. It required the development of mechanisms to consider past contractor performance in contract awards and modified reporting requirements and other regulations to make them less burdensome. The use of past performance in source selection decisions, still relatively in its infancy, has the potential to make DoD more like a commercial customer, putting greater emphasis on a potential supplier's track record.

FASA required DoD to establish pilot programs[12] to "jump start" reform by demonstrating the use of commercial practices and the acquisition of commercial products. Both represent major changes from standard DoD practice. In theory, commercial specifications would open competition to a broader range of firms and allow defense-oriented firms more leeway to develop innovative solutions. The use of commercial components is a logical consequence of the use of commercial specifications.

The use of cost as an independent variable (CAIV) represented a change in DoD's requirements process. Under CAIV, total life-cycle cost is as important as performance and schedule in weapon system development. This does not imply that cost was not considered in the past; rather, CAIV prescribes that cost is to be incorporated as a trade parameter in the design process. Only a few key performance parameters are prescribed. If cost targets are not met on the first iteration, trades are considered involving performance, schedule, and cost.

The shift in emphasis from development and procurement cost to total life-cycle cost is a distinctive feature of CAIV. Acquisition personnel in the early stages of the process face several difficulties in focusing on support costs. For one thing, there is the

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11 *The Defense Acquisition Revolution, DoD's AR Mission* [Online], (December 19, 1997), Available: http://www.acq.osd.mil/ar/mission.htm [December 29, 1997], and "Mandate for Change, Plan" presented by Secretary of Defense William Perry to the House Armed Services Committee and the Governmental Affairs Committee, February 1994.

12 Based on nominations from the military services, DoD designated the following programs as statutory Defense Acquisition Pilot Programs (DAPPs) in December 1994: Joint Direct Attack Munition (JDAM), Fire Support Combined Arms Tactical Trainer (FSCATT), Joint Primary Aircraft Training System (JPATS) , Commercial Derivative Engine (CDE), Commercial Derivative Aircraft (CDA)/ Non-Developmental Airlift Aircraft (NDAA).

classic time-horizon problem. Support occurs several years in the future, and application of a reasonable discount rate often renders these costs a small factor in the decision process. Furthermore, the regular rotation of military personnel and the organization of program offices create incentives to emphasize the more immediate needs to contain development and procurement costs. Even if people want to consider support costs, they do not always know *how* to estimate them early in the process. Often, consideration of support cost drivers is the best that can be done. If these can be determined accurately, acquisition decisions can contribute to more reasonable support costs. In this handbook, we emphasize initiatives to reduce development and procurement costs. In cases where support costs are considered, they are identified explicitly.

The broad process of acquisition reform initiated over the past 3 years has created an environment hospitable to CAIV. The regulatory relief measures in FASA are useful in instituting commercial practices in order to meet aggressive cost targets.

The aggressive CAIV cost target is set by considering and exploiting benefits that arise from the introduction of new processes and practices. These include integrated product and process development (IPPD); acquisition reform; use of commercial practices, specifications, and components; and defense enterprise leanness. CAIV also encompasses some more traditional initiatives in the DoD arsenal, such as multiyear procurement.

Of course, any initiative needs time and consistency to succeed. Funding instability can be a serious obstacle to success. When schedule, funding, performance, or deliveries are changed after contract award, the contractor views this turbulence as an opportunity to restructure the program with added cost. If quantity is cut, unit cost rises almost inevitably, despite recent efforts to decouple unit cost and quantity.

4. Defense Contractor Initiatives

Enterprise leanness covers a series of initiatives applied within a contractor's operation to improve the efficiency and flexibility of processes and eliminate wasteful and unnecessary functions.

Industrial leanness, first adopted on a wide scale by the automobile industry, has the focused objective of making an enterprise more competitive and able to generate output at lower cost. The leanness concept incorporates a variety of initiatives such as:

- ***Integrated product and process development (IPPD):*** IPPD is a process that integrates all activities from product concept through production and field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing processes to meet cost and performance objectives. In recent years, design practices have changed dramatically, in response to both the availability of new technology and the change in customer demand. Computers have made possible computer-aided design and virtual prototyping. Potentially, such practices make for better designs, since the implications of design changes can be readily seen, and different versions of a design can be produced quickly and inexpensively. IPPD has the potential to transform both design and manufacturing and is expected to increase research, development, test, and evaluation (RDT&E) costs but to pay off later in the process.

- ***Activity-Based Cost Awareness:*** Before an enterprise can achieve leanness, it must measure the true costs of its component processes and act on that information to eliminate activities that do not add value to the customer.
- ***Adaptive Enterprise Architecture:*** The lean enterprise retains processes that are cost competitive or processes that define a core or strategic competency. Make/buy analysis helps the firm to eliminate operations that are not competitive with "best in class" suppliers. These noncore or uncompetitive processes are then subcontracted. The core and cost-competitive processes are organized into flexible common-process cells.
- ***Just-In-Time Production Control:*** The lean enterprise will employ just-in-time (JIT) production control and inventory policies. Many benefits are derived from JIT. Less work in process inventory means less working capital is employed during production. The JIT factory assumes a continuous flow of components; continuous flow allows process variations to be studied, characterized, and managed. Quality problems are found more easily, and fewer units require rework or scrapping. Engineering changes can be incorporated more smoothly, with fewer components discarded due to obsolescence, because the inventory is smaller.
- ***Electronic Infrastructure:*** The lean enterprise employs computerized systems to plan and control the production environment and facilitate rapid communications with suppliers. Suppliers are linked to the factory's material-management system and deliver components in kits to specific work sites when electronically cued. Purchasing is conducted using electronic commerce technology. An electronic information network connecting engineering, factory, and suppliers provides access to detailed specifications, process descriptions, design databases and tools, models and simulations, and other data. All parties have access to benchmarking metrics[13] that tell everyone how well the organization is performing.

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[13] The need for appropriate benchmarks to track progress is part of what is recommended to implement recent cost-reduction initiatives. The International Motor Vehicle Program benchmarks best practices, assesses industry performance standards, and develops international comparisons of assembly plants,

Many defense aerospace companies are participating in the Lean Aerospace Initiative (LAI), a program to define and foster dynamic, fundamental change in both the US defense aircraft industry and government operations. By building on and extending the "lean" paradigm developed in the commercial world, the MIT-based program seeks to develop the knowledge base that will lead to more affordable systems with increased efficiency and higher quality. Longer-term results sought include enhancing the viability, technological superiority, and competitiveness of the US defense aircraft industrial base.[14]

Our experience in surveying a variety of industry initiatives in the 1980s indicates that years of management commitment are necessary to achieve significant savings.[15] If the initiatives represent major changes from standard management practices, savings cannot come without a substantial learning period. For example, it took the Air Force and Lockheed several years to effect a smoothly functioning IPPD process for the F-22 fighter aircraft program.

The recent consolidation of the defense industry raises questions about the continuing implementation of cost-reduction initiatives. In the commercial world, widespread competition in many industries gives companies incentives to cut costs and to get innovative products to market quickly. In industries with few competitors, antitrust laws and the threat of other firms entering the marketplace help to moderate the dangers of monopolistic behavior. In defense, the government is dealing with three large, vertically integrated prime contractors. DoD officials spurred on the consolidation of the aerospace industry in the hopes of reducing overhead expenses. The small number of companies, however, limits the possibilities for future competition. Their vertical integration raises the issue of whether DoD can create appropriate incentives for subcontractor and vendor competition. Moreover, a large, secure company has less incentive to implement cost-reduction initiatives to remain competitive. There is, however, still an incentive to cut costs in order to preserve ongoing programs.

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engine plants, stamping plants, and suppliers. Today, benchmarking is receiving increased emphasis both under the "reinventing government" initiative and in private sector initiatives for process improvement.

14 See description of Lean Aerospace Initiative at http://web.mit.edu/afs/athena/org/c/ctpid/www/.

15 J. Richard Nelson, James Bui, John J. Cloos, and David R. Graham, "Management Practices To Achieve More Affordable NASA Programs," Document D-1297, Institute for Defense Analyses, June 1993, and John J. Cloos and J. Richard Nelson, "A Cost-Reduction Strategy for Weapon System Acquisition," Paper P-2410, Institute for Defense Analyses, December 1990.

C. DEFENSE AND COMMERCIAL: SIMILARITIES AND DIFFERENCES

The traditional model of defense practices is that of a highly regulated acquisition process. Defense industry leaders have advocated greater use of commercial practices and procedures, and the DoD has recently been moving in that direction. A discussion of the similarities and differences between defense and commercial product environments is appropriate to a better understanding the risks and opportunities posed by these new ways of doing business.

The degree of similarity between defense and commercial products depends first on the type of system being procured and second on whether one is considering the system as a whole, subsystems, or individual components.

Defense and commercial products are most similar at the level of the subsystem and individual component. In some cases, commercial technology is as advanced as or more advanced than military technology, particularly when it comes to electronics and computers. In one such case, before reform, a commercial company was planning to introduce a radio with special encryption features. Because the item had not been sold in substantial quantities yet, the company would have had to set up a new accounting system to provide the required cost data for DoD. When the company refused to undertake the additional costs, DoD had to buy older technology, while the new technology was sold to commercial customers.[16]

By contrast, there are systems for which defense technologies must be more sophisticated, robust, or reliable than commercial industry. Fighter aircraft require capabilities in terms of speed, survivability, and observability that are much more demanding than any commercial aircraft. Airborne information processing and integration systems are advancing rapidly in defense, and advanced avionics and sensors are also required. Requirements for aircraft carrier–landing capability and short takeoff and vertical landing (STOVL) in the new Joint Strike Fighter, for example, are unique to defense.

DoD has a completely different personnel system from commercial industry. Military and civil service personnel have career protections and policymakers rotate frequently. DoD resources are public rather than company funds, and there are no clear indicators of success or failure as in commercial industry. Work is performed under the scrutiny of Congress and various watchdog organizations. The government has tried to

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16 "Mandate for Change, Plan" presented by Secretary of Defense William Perry to the House Armed Services Committee and the Governmental Affairs Committee, February 1994.

maintain ownership of the technical data underlying its systems to organize its support processes, but DoD has generally preferred to have organic support of its most critical systems.

By contrast, most commercial developments employ private capital, involve risk, and are ventures undertaken to generate profits. The profitability or success of a commercial development is influenced by the magnitude of development and production costs, the cost of capital, pricing policy, market size, competition and market capture, product quality and performance, timing, and other factors. Commercial developments are governed by corporate policies, a set of practical specifications, and the applicable codes and regulations covering consumer safety and other public concerns.

Commercial industry has strong incentives to manage and contain development costs and to safeguard investments in proprietary designs, technologies, processes, and information. Typical commercial practices include the following:

- Preference for reuse of existing hardware and software designs.
- Limited development testing, or testing covering only routine or unexceptional operating conditions.
- Ownership and capitalization of tooling.
- Limited data disclosure, identification of many data categories as proprietary or trade secrets, extensive use of patents, copyrights, and trademarks.
- Flexible approaches to configuration management, including freedom to alter, improve, or abandon products at will and without notice.

Production scale is another important influence. Commercial products developed for the United States or international consumer markets are often produced in great volume. Automotive programs, for example, often produce hundreds of thousands of units per year, and consumer electronic programs can experience even higher production rates. The scale of consumer or automotive production volume can support highly automated factories that employ the most cost-effective techniques and processes. By contrast, defense programs rarely achieve the production scale of the consumer or automotive sectors, and they are frequently characterized by low volume, many design changes, and annual funding uncertainties.

Given these similarities and differences, is it appropriate for DoD to shift from its traditional practices to the commercial model? A Defense Science Board (DSB) Task

Force on the Joint Advanced Strike Technology (JAST) Program considered this issue. It found that the best practice is a mix of traditional DoD and commercial.[17]

The differing needs of the defense and commercial worlds have produced different levels of progress in a range of technologies. In some cases, DoD will have to continue its own developments, while in others it must act more like a commercial customer to take advantage of commercial technology investments. The widely differing nature of the systems that DoD acquires means that the mix of defense and commercial practice must be tailored to the type of system being acquired.

Motivations also differ. DoD often needs to push the state of the art to make sure that the system is good enough to subdue the enemy. Even if the system is affordable, it will not be bought if it does not achieve mission superiority. Commercial industry, on the other hand, tends to develop low-risk incremental technologies. Requirements typically follow these motivations, with DoD's requirements driven by the mission and commercial requirements driven by customer needs and the desire to get to market quickly. In several cases, a hybrid model is regarded as preferred. Since JAST is an advanced technology product, these recommendations might be regarded as the lower limit for commercial practice.

The greatest potential gains in moving from traditional to commercial practices are in the area of risk management. While it is probably not possible to get away from annual congressional decisions on large programs, the DoD can avoid its own perturbations in programs once Engineering and Manufacturing Development (EMD) has been approved. The task force recommended government-industry cooperation in the production of effective and affordable products.

Even the strongest proponents of commercial practice emphasize that "one size does not fit all." The new DoD policy encourages tailoring of acquisition policies and practices to the needs of the program, not uncritical adoption of commercial practice in all cases. The DoD cannot always adopt best commercial practices, because it is a different type of customer with different needs. However, the adoption of appropriate commercial practices has the potential to reduce costs and broaden the base of industry ready to serve DoD.

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17 The rest of this section draws heavily from the task force's "Report of the Defense Science Board Task Force on the Joint Advanced Strike Technology (JAST) Program," September 1994.

D. CATEGORIES OF INITIATIVES

We have grouped the initiatives in our taxonomy into five categories, based on where in the acquisition process the initiative is used:

- *Design and test initiatives* involve the product design phase primarily or have to do with product testing.
- *Production and support initiatives* have to do with the production process or the facilities used for production.
- *Program management initiatives* involve changes in government or industry management practices or logistical changes in the business process.
- *Government acquisition initiatives* depend on government decisions for their application.
- Finally, *corporate policy initiatives* relate to corporate decisions made by top officials, such as mergers and personnel policies.

The taxonomy, explained in Chapter II and presented in Chapter III, is the first step to evaluating the cost impact of the initiatives. It provides information on specific initiatives that suggest some initial steps toward evaluation. For example, the analyst should obtain information on the actual steps occurring to implement the initiative and evaluate them against what other programs have done. In some cases, initiatives take a long time to yield benefits, so a time line of when benefits are expected to occur is needed. In many cases, a program is implementing several initiatives simultaneously. While this can increase the probability of success, there may be interdependencies among the initiatives. It is important to avoid double counting in evaluating the potential impact of initiatives.

For each initiative, Chapter III provides interdependencies with other initiatives, history of implementation, hypothesized cost impact, benefits, caveats, results (where available), and a list of things to look for when assessing the initiative.

E. OVERVIEW OF RECOMMENDED ANALYTIC APPROACH

Chapter IV contains the details of an approach to evaluating the cost impact of the initiatives. Given that information about the initiatives comes from many sources, the approach provides a method for analyzing the information systematically. It uses net program cost savings as the measure of effectiveness. The approach analyzes potential savings by contract line item number (CLIN), work breakdown structure (WBS), and cost element (direct cost, indirect cost, and fee).

The approach recognizes that multiple initiatives may be implemented simultaneously, and it may be impossible to disentangle the separate effects of each. Analysts can use the interdependency guide in Chapter III to avoid double counting and to identify situations in which the impact of one initiative may be lessened because of another.

II. STRUCTURE OF THE TAXONOMY

A. CATEGORIES OF INITIATIVES

In creating our taxonomic structure, we included initiatives that are applicable to a variety of products and industries. Our taxonomy consists of the following five categories:

1. *Design and test*—initiatives that primarily involve the product design phase or have to do with product testing. Table II-I lists and defines the initiatives included in this category.
2. *Production and support*—initiatives having to do with the production process or the facilities used for production. Table II-2 lists and defines these initiatives.
3. *Program management*—initiatives involving changes in management practices or logistical changes in the business process. Table II-3 lists and defines the initiatives in this category.
4. *Government acquisition*—initiatives that are unique to the procurement process used by the government. Table II-4 lists and defines the initiatives in this category.
5. *Corporate policy*—initiatives that are corporate-level decisions. Table II-5 lists and defines these initiatives.

In cases where an initiative belongs to more than one category, we placed it in the most applicable category. Thus, each initiative appears in only one category.

B. LAYOUT OF STRUCTURE

The initiatives in Chapter III are organized by the categories described in the previous section. Within the categories, we name and define each initiative using generally accepted definitions whenever possible. For each initiative, the discussion is divided into seven parts. We describe the initiative in terms of its (1) interdependencies, (2) history of implementation, and (3) hypothesized effect on cost. We also explain the (4) benefits of the initiative, provide (5) caveats for its use, give (6) results of its past use, if any, and tell analysts (7) what to look for in terms of useful data and to help them avoid pitfalls in analysis. Each of these parts is explained further in the following subsections.

Table II-1. Design and Test Initiatives

Initiative	Definition
Computer-Aided Design (CAD)	The use of hardware and software-based design tools (such as workstations and design and simulation software packages) for creating, testing, and evaluating product designs. Typically used in conjunction with computer-aided manufacturing (CAM) in order to take account of manufacturing issues in the product design.
Concurrent Engineering	A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. Under this approach, the developers, from the outset, address all elements of the product from conception through disposal, including quality, cost, schedule, and user requirements.
Design Assurance	A management and engineering process in which product designs are reviewed on an on-going basis to ensure that they meet the intended user requirements and that needed design modifications are made before production.
Design for Manufacture and Assembly	The planned use of product design to streamline and simplify the manufacturing and assembly processes, thereby reducing the cost of production and support.
Integrated Product and Process Development (IPPD)	A process that integrates all activities from product concept through production and field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing processes to meet cost and performance objectives. This includes: concurrent development of products and processes, continuous life-cycle planning, and multidisciplinary teamwork.
Modeling and Simulation versus Testing	The use of analytical models or computer simulation in lieu of traditional testing.
Virtual Prototyping	The use of a virtual prototype, in lieu of a physical prototype, for test and evaluation of specific characteristics of a candidate design. (A virtual prototype is a computer-based simulation of a system or subsystem with a degree of functional realism that is comparable to that of a physical prototype.)

Table II-2. Production and Support Initiatives

Initiative	Definition
Automated Test Equipment	Equipment capable of performing product testing with minimal operator involvement.
Computer-Aided Manufacturing (CAM)	Using a computer system to control or enhance the manufacturing process. Often coordinated with computer-aided design (CAD).
Flexible Automated Manufacturing Process	A process in which the manufacturing equipment and machinery are capable of performing more than one task. The changeover between tasks should not require an unreasonably long lead-time.
Flexible Work Force	A system in which the labor force of a company is capable of performing multiple jobs depending on the current need. This may require labor-management agreements in unionized plants.
Just-in-Time (JIT) Manufacturing	A management principle that minimizes inventory by requiring that the level of supplies and equipment present exactly equals the amount required by the process.
Overhead Reductions	Measures taken to reduce the costs not directly associated with the design or production of a product. While overhead structures are different in each company, typical overhead functions include facility maintenance, insurance, facility depreciation, and administrative expenses.
Reduced Cycle Time	Actions taken to decrease the amount of time required for a particular activity.
Supplier Certification	A process in which a company evaluates the performance of its suppliers and certifies suppliers as qualified. Often results in long-term relationships between contractors and suppliers.
Use of Commercial Components	The process of using existing products, technology, and software in the design and manufacture of a product.

Table II-3. Program Management Initiatives

Initiative	Definition
Activity-Based Costing (ABC)	An accounting system that first determines which processes and materials are consumed in creating a product, and then uses this knowledge to determine the product's cost. Where traditional systems allocate indirect costs with standard measures such as labor hours or machine hours, an activity-based system will create unique cost drivers designed to capture the resource utilization of each product.
Continuous Process Improvement (CPI)	The commitment of resources to improving organizational processes, including management, engineering, production, and support. These processes are continuously scrutinized for improvements.
Electronic Commerce and Electronic Data Interchange (EC/EDI)	Electronic commerce is the paperless exchange of business information using Electronic Data Interchange, Electronic Mail, computer bulletin boards, facsimile, Electronic Funds Transfer, and other similar techniques. EDI is the computer-to-computer exchange of business information using a public standard (e.g., ANSI X12 or EDIFACT).
Integrated Product Teams (IPTs)	Groups of specialists from different areas and organizations that are assembled to address specific tasks. Can be firm-specific, across firms, or government-industry.
Make/Buy Outsourcing	The process of deciding whether to manufacture a component or assembly within the organization or to subcontract the work to an external vendor.
Simplification of Management Hierarchy	A reduction in the number of management personnel or the number of levels in the management structure. Rationale is overhead and direct cost reduction through the elimination of non-value added activity.
Total Quality Management (TQM)	A fundamental rule or belief for operating an organization aimed at continually improving performance over the long term with a focus on processes and the use of process action teams.
Vertical Partnering	The teaming up of a contractor with a customer, subcontractor, or supplier. Often involves sharing technology and forming IPTs.

Table II-4. Government Acquisition Initiatives

Initiative	Definition
Commercial Standards	Having production adhere to commercial industry standards as opposed to requiring military-unique specifications and standards.
Cost as an Independent Variable (CAIV)	The process of considering an aggressive cost target along with performance and schedule targets and making tradeoffs among these objectives.
Contract Incentives	Contract provisions designed to induce desired contractor behavior through higher fees. Types include incentive fee or award fee, and contracts can be cost plus or fixed-price. Incentive fees are typically tied to cost performance. Award fees are broader and can target a variety of goals, including delivery dates or reliability and maintainability.
Dual-Source Competition	Use of more than one source in production. Multiple sources are usually carried over from development. In some cases, a second source has been developed after several lots of sole source production.
Multiyear Procurement (MYP)	Contracting for more than a single year's buy in a single contract, as an alternative to a series of annual contracts. Through economic quantity buys, MYP is expected to reduce the cost of procuring a weapon system.
Performance-Based Specifications	Specifications that describe the performance requirements of a product rather than its detailed physical or technical characteristics. The contractor is allowed to determine how these performance requirements are met.

Table II-5. Corporate Policy Initiatives

Initiative	Definition
Corporate Program Investment	A corporate commitment to bear all or part of the cost of an initiative or a program, in order to keep the program affordable. The funds expended by the company are sometimes referred to as a "management contribution."
Mergers and Acquisitions	A strategic corporate action taken by one company to combine with or acquire another company. The action typically includes restructuring of the combined entity.
Personnel Policies	The policies and practices of a company that deal with its employees (e.g., salary and benefits, incentives, and assignments).
Plant Location and Overhead Allocation	A strategic choice of development or production site to take advantage of regional differences in labor costs, labor/management structures and laws, expertise available, or other resources.

1. Interdependencies

Many of the cost-reduction initiatives are interrelated, in either a positive or a negative way. In Chapter III, we identify the interdependencies among the initiatives so that readers can evaluate the possibility of double-counting benefits, of initiatives facilitating others, or of initiatives making it harder to do other initiatives.

For example, the use of a virtual prototype may strongly facilitate concurrent engineering, integrated product and process development (IPPD), integrated project teams (IPTs), design assurance, and design for manufacture and assembly. All of those initiatives require integrated planning, integrated teamwork, and constant redesign and design testing.

In a similar way, one particular cost-reduction initiative may be facilitated by another. For example, the development of a strong computer-aided design (CAD)/computer-aided manufacturing (CAM) platform would be a precursor to developing a full virtual prototype and virtual environment.

Finally, implementation of some initiatives may be detrimental to implementation of others. For example, a reduction in overhead may reduce a contractor’s ability to fund the development of CAD/CAM hardware and software tools, which would have provided a programming platform for development of a virtual prototyping capability. In this case, an immediate cost reduction is obtained through overhead reduction, but the opportunity for other initiatives may be foregone.

Interdependencies between initiatives potentially create a problem of double counting. The savings of the initiatives do not necessarily add in a linear way, based on the savings generated by each, but combine into a set of initiatives for the program that must be assessed as a whole.

2. History of Implementation

Where available, we provide a history of implementation for each initiative. This can include information on early implementers or on DoD policy memos.

3. Hypothesized Effect on Cost

Table II-6 shows our hypothesized impact summary for each of the initiatives included in our taxonomy. We divided this summary into the four components of a typical program’s life cycle: Program Definition and Risk Reduction (PDRR), Engineering and Manufacturing Development (EMD), Production, and Operations and Support (O&S).

Table II-6. Summary of Hypothesized Effects of Cost-Reduction Initiatives

	PDRR	EMD	Production	O&S
Design and Test				
CAD*	+/–	+/–	+	+
Concurrent Engineering	–	+/–	+	+
Design Assurance	–	–	+	+
Design for Manufacture and Assembly	–	+/–	+	+
IPPD	–	+/–	+	+
Modeling and Simulation versus Testing*	+	+		+/–
Virtual Prototyping*	+/–	+/–		
Production and Support				
Automated Test Equipment*		+	+	+
CAM*		+	+	
Flexible Automated Manufacturing Process*		+	+	
Flexible Work Force*	+	+	+	+
JIT*		+/–	+/–	
Overhead Reductions		+	+	+
Reduced Cycle Time	+	+	+	+
Supplier Certification*		+	+	+
Use of Commercial Components		–	+	+/–
Program Management				
ABC*			+	
CPI	–	–	+	+
EC/EDI*		+	+	+
IPTs	–	+/–	+	+
Make/Buy Outsourcing			+	
Simplification of Management Hierarchy		+/–	+/–	
TQM	–	–	+	+
Vertical Partnering*		+	+	+
Government Acquisition				
Commercial Standards		+	+	+/–
CAIV	–	+/–	+	+
Contract Incentives	+/–	+/–	+/–	
Dual-Source Competition	–	+/–	+/–	–
MYP	–	–	+/–	
Performance-Based Specifications		+/–	+	
Corporate Policy				
Corporate Program Investment		+/–	+	
Mergers and Acquisitions	+/–	+/–	+/–	+/–
Personnel Policies	+/–	+/–	+/–	+/–
Plant Location and Overhead Allocation*	+/–	+/–	+/–	

Note: A "–" denotes costs in the form of cost increases and a "+" indicates benefits in the form of cost reductions. In some cases, there is a mix of costs and benefits, and it is uncertain which are larger. A "*" indicates that a start-up investment is required.

In addition, we included an asterisk to identify those initiatives that require an investment cost. For each component, we identify whether we expect the initiative to

1. yield cost savings (denoted by a “+” in cells with the darkest shading in Table II-6),
2. result in an additional cost being incurred (denoted by a “–” in cells with the lightest shading),
3. have an effect that could either increase the cost or result in cost savings (denoted by “+ /–” in cells with medium shading), or
4. have no appreciable effect (blank cells).

Although we list the benefits for each initiative separately, it is important to realize that many of the initiatives are only successful when used together. For instance, a key component of IPPD is the use of IPTs. Another example is that successful implementation of Just-in-time manufacturing requires initiatives such as vertical partnering or supplier management to ensure that an excellent relationship exists between the contractor and the supplier.

4. Benefits

Under this heading we list the individual benefits to the particular initiative. We highlight potential cost savings and explore benefits it may provide other than cost savings.

5. Caveats

Here we highlight potential cost increases from the initiative and explore other risks to its use.

6. Results

Where available, we present the results of use of the particular initiative. These results were either gleaned from early experiences or are the results of specific research.

7. What To Look For

Finally, we provide information on the types of data that will shed light on the issue of savings from a particular initiative. Asking for appropriate information early in the process is crucial to developing a credible analysis of cost savings. The analyst will have to determine if the current implementation of the initiative is similar to prior implementations. We also provide a method for avoiding pitfalls in oversimplifying the analysis.

C. YOUR COMMENTS

We invite you to share your experiences with cost-reduction initiatives and your comments about our taxonomy. Please provide them via the tear-out pages provided at the end of this document.

III. TAXONOMY OF COST-REDUCTION INITIATIVES

A. DESIGN AND TEST INITIATIVES

1. Computer-Aided Design (CAD)

The use of hardware- and software-based design tools (such as workstations and design and simulation software packages) for creating, testing, and evaluating product designs. Typically used in conjunction with computer-aided manufacturing (CAM).

Interdependencies

CAD is a tool that directly facilitates the use of virtual prototyping, modeling and simulation, concurrent engineering, integrated product and process development (IPPD), and integrated product teams (IPTs). The CAD platform assists in the creation of a computer model and virtual environment that is the basis of the virtual prototyping and modeling and simulation. Further, the computer model and virtual testing environment support the integrated planning and teaming efforts required for concurrent engineering, IPPD, and IPTs.

History of Implementation

- 1970s: Two-dimensional CAD was used.
- 1981: Dassault Systems, a French company, marketed computer-aided, three-dimensional interactive application (CATIA).

Hypothesized Effect on Cost

- Development Engineering and Producibility/Engineering Planning: The CAD initiative, by reducing the design-cycle time, potentially reduces the cost of engineering development and planning. However, the ability to change the design rapidly may result in more iterations of the design, to the point where costs increase.
- Prototype Manufacturing: By allowing faster and cheaper testing, the CAD initiative may reduce the prototype manufacturing cost.
- Engineering Change Orders: By allowing faster and more thorough testing, the CAD initiative potentially eliminates some engineering change orders.
- Operating and Support Costs: May be lower due to improved design, particularly in the early years.

Benefits

For many years, manufacturers have used CAD to create designs for parts and products. One of the benefits of computer-aided design is that it provides flexibility to easily examine various design options. Also, many CAD systems can perform engineering tests and evaluate the performance of a design.

The major benefit of using CAD occurs when it is coordinated with computer-aided manufacturing (CAM). An integrated CAD/CAM system can result in a significant reduction in the time and cost required for design through production.

Caveats

CAD involves a large nonrecurring equipment setup cost. However, equipment is flexible enough to be used across projects. A CAD system may lead to more design iterations and a possible increase in Development Engineering costs. This cost should be offset by the resulting improvements in the design of the product.

Results

CAD is widely used in both government and commercial work and has become a standard design tool.

What To Look For

- Age of the CAD system; experience level of the organization with CAD.
- Cost of customizing for this program—any up-front costs? Does the CAD tool have reuse potential?
- Specific types of planned savings, such as from earlier problem recognition and resolution or from replacement of manual design effort.
- Links between design and manufacturing processes.
- Cost of additional design iterations made possible by CAD.

2. Concurrent Engineering

A systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. Under this approach, the developers, from the outset, address all elements of the product from conception through disposal, including quality, cost, schedule, and user requirements.

Interdependencies

Concurrent engineering facilitates the integrated product and process development (IPPD) initiative by forcing the integrated consideration of development, manufacturing, support and all life-cycle issues in the context of product design. This is the underpinning of the IPPD approach.

Concurrent engineering is facilitated by, in fact subsumes, several other design initiatives. The design assurance initiative requires on-going design review to ensure compliance with user requirements and to ensure that design modifications are undertaken before production. Design for manufacture and assembly seeks to streamline and simplify the manufacturing and assembly processes by appropriate product design planning. Both of those initiatives are elements of concurrent engineering.

Modeling, simulation, CAD/CAM, and virtual prototyping also support concurrent engineering. All of those initiatives make the design process more flexible, faster, and more capable of taking into account manufacturing, support, and other cost considerations that are part of the concurrent engineering initiative.

History of Implementation

- December 1988: IDA published "The Role of Concurrent Engineering in Weapon Systems Acquisitions" (Robert I. Winner, et al., IDA Report R-338, Institute for Defense Analyses, December 1988).
- March 9, 1989: The Under Secretary of Defense (Acquisition) issued a memorandum adopting concurrent engineering as part of DoD's Total Quality Management (TQM) policy.

Hypothesized Effect on Cost

- Development: PDRR costs will almost certainly be higher due to involvement of more people, while EMD costs could be higher or lower.
- Production: Costs are expected to be lower.
- Engineering Change Orders: Expected to decline, both in number and complexity.

Benefits

Concurrent engineering is expected to lead to a substantial decrease in the number of engineering change orders, problems of engineering incompatibility in the design, a reduction in product development time, significantly reduced manufacturing costs, a reduction in scrap and rework and an improvement in product quality.

Caveats

Because concurrent engineering involves multiple engineering and management disciplines as well as a change in the basic approach in the management of the program, it may take several years for significant benefits to emerge. However, the costs occur immediately. Those costs include engineering and management time, along with enabling technologies such as CAD/CAM and virtual prototyping.

Results

Previous empirical analyses have estimated reduction in engineering change orders of 50% in early production, reductions in development-cycle time of 40% to 60%, reductions in manufacturing costs of 30% to 40%, and reductions in scrap and rework of as much as 75%.

What To Look For

- Length of experience with concurrent engineering concepts; past record on savings.
- Whether the support structure is in place to carry out concurrent engineering, such as CAD/CAM tools.
- Whether all elements of product design, production, operation, support and disposal are included in the concurrent engineering plan and whether all of the required disciplines are included in the process.
- Realistic timing of savings projections.

3. Design Assurance

A management and engineering process in which product designs are reviewed on an on-going basis to ensure that they meet the intended user requirements and to ensure that needed design modifications are made before production.

Interdependencies

Design assurance facilitates concurrent engineering, IPPD, and IPTs by providing an on-going design review that takes account of numerous factors over the life cycle of the product. It also facilitates design for manufacturing and assembly by providing the continuing review that is necessary to ensure that the design meets the manufacturing and assembly objectives.

Design assurance is facilitated by the application of CAD/CAM and by modeling and simulation. Both of those initiatives assist in creating, testing, evaluating, modifying, and verifying designs throughout the design and production processes.

Design Assurance is a component of a continuous process improvement (CPI) and total quality management (TQM) program.

History of Implementation

No information.

Hypothesized Effect on Cost

- Development Engineering: Cost expected to increase.
- Engineering Planning: Cost expected to increase.
- Production: Cost expected to decrease due to fewer engineering change orders.
- O&S: Cost expected to decrease due to design improvements.

Benefits

The design assurance approach is to identify, define, and understand the user requirements in detail, to track the expected results as the design evolves, to verify that the design will meet the final requirements, and to ensure that the design changes are made before the product goes into production.

Design assurance continually focuses the design and redesign work on the end-user's requirements, potentially providing a better design and a product of higher quality.

Design assurance potentially reduces technical, schedule, and cost risk by ensuring, at any point in the development process, that a design does meet the user requirements. This helps avoid significant changes late in the design process based on unforeseen mistakes or failure to meet requirements, which in turn reduces the likelihood of unanticipated schedule or cost growth.

Design assurance potentially reduces the number of engineering change orders/proposals in the production phase by stabilizing the design earlier, by taking account of production issues while the product is still in the design phase, and by ensuring that design modifications are made before production begins. Avoiding engineering change orders/proposals would lead to avoidance of both direct cost and schedule disruptions. This is particularly significant where design changes would cause significant configuration changes, such as in subsystem interfaces, in the maintenance concept, or in the user interface.

Design assurance would be particularly important in cases where the user requirements were changing, perhaps because of a changing threat, a changing technology, or even a changing funding level. It would provide on-going, real-time assurance that changes in requirements were being incorporated into the design.

Design assurance potentially could reduce operation and support costs by ensuring that requirements for efficient operation and support were incorporated into the product design.

Caveats

The cost of instituting a design assurance approach is the additional time and expense required to continually review the design, to verify the design against the user requirements, and to confirm that the changes have been made before the beginning of production. If modeling, simulation, or CAD/CAM tools need to be developed for this purpose, they would impose additional cost. Further, such reviews add to the management overhead of the program, potentially leading to schedule delays without necessarily causing improvements in the design of the product.

The pressure to get funding committed and move programs into production rapidly is an obstacle to design assurance.

Results

Design assurance has been applied successfully, especially as part of TQM efforts by commercial firms and government contractors.

What To Look For

- Length of experience with design assurance concepts; realistic timing of savings.
- Whether the design reviews are included at all stages of product development, such as approval of the design review team before proceeding to production.
- Whether all functional areas are included in the review process, such as manufacturing, engineering, and operations and support.
- High degree of involvement by the requirements community.

4. Design for Manufacture and Assembly

The planned use of product design to streamline and simplify the manufacturing and assembly processes, thereby reducing the cost of production and support.

Interdependencies

The design for manufacture and assembly initiative supports concurrent engineering, IPPD, and IPTs since those initiatives take account of development, production and support factors in the acquisition process.

The design for manufacturing and assembly initiative is supported by the design assurance initiative, since the latter provides on-going review of designs to ensure they meet user, production, and operational support requirements.

History of Implementation

- 1980: General Electric initiated the Design for Assembly Program. This program was derived from a technique Hitachi developed called the Assemblability Evaluation Method.
- 1985: Boothroyd Dewhurst, Incorporated, developed Commercial Design for Assembly software. The software has since been licensed to approximately 300 companies in the United States and Europe.

Hypothesized Effect on Cost

- Development: Costs expected to be higher in PDRR, either higher or lower in EMD.
- Production: Costs expected to be lower due to improved manufacturability.
- O&S: Cost expected to be lower due to improved design.

Benefits

The design for manufacture and assembly initiative is intended to streamline and simplify the manufacturing and assembly processes by considering production issues early in the design of the product. The process includes analysis of tolerance values, parts movement during fabrication and assembly, complexity of product and number of parts, and assembly environment (manual or automated).

For example, the total number of parts in a product is considered to be a key determinant of the cost of manufacturing, assembly, provisioning, maintenance, and support. A primary focus of this initiative is to reduce the number of parts through product design, thereby potentially substantially reducing manufacturing and assembly costs. However, design for manufacture and assembly also looks for other simplifications of the manufacturing and assembly process.

Design for manufacturing and assembly, by looking downstream in the acquisition process, potentially avoids the need to make some design changes late in the acquisition cycle when production issues become apparent. By moving the design changes to an earlier point in the process, the changes would be less expensive and would involve fewer other factors. For example, the maintenance concept would not have been as fully defined and therefore might require fewer changes if the design changes were made earlier.

Caveats

The cost of the design for manufacturing and assembly initiative is the engineering and management time to expand the design reviews to include production and support issues. This would involve production, assembly and support personnel, as well as design, manufacturing, and engineering.

The benefits of this initiative are based on the assumption that design requirements are sufficiently flexible to allow manufacturing and assembly considerations to become a significant part of the design decision. However, the validity of that assumption depends upon the specific case. Further, user requirements may change substantially during the development phase and outweigh manufacturing considerations from a performance viewpoint.

Results

One analysis, based on General Electric’s application of design for manufacturing and assembly to hundreds of designs, concluded that a 20% reduction in parts count is a realistic goal, along with a 40% reduction in assembly labor.[18] In another study, Ford Motor Company reported savings in excess of $1 billion through widespread application of the Boothroyd Dewhurst software system.[19]

What To Look For

- Contractor’s length of experience with this and similar initiatives; experience and track record on past programs.
- Whether the design requirements are flexible enough to allow manufacturing and assembly issues to influence product design.
- Whether the required personnel representing manufacturing, assembly, production, support, and other areas are included in the reviews.
- Whether there are measurable indicators of streamlining the design and manufacturing processes, such as parts count and projected labor hours.

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[18] Gerard Hock, “After 5 Years, What Has GE Learned from Design for Assembly?” Presentation to the International Conference on Product Design for Assembly, 1986.

[19] Peter Dewhurst, unpublished correspondence, September 20, 1988, cited in Robert I. Winner, et al., “The Role of Concurrent Engineering in Weapons System Acquisition,” IDA Report R-338, Institute for Defense Analyses, December 1988.

5. Integrated Product and Process Development (IPPD)

A process that integrates all activities from product concept through production and field support, using a multifunctional team, to simultaneously optimize the product and its manufacturing processes to meet cost and performance objectives. This includes: concurrent development of products and processes, continuous life-cycle planning, and multidisciplinary teamwork.

Interdependencies

Integrated product teams (IPTs) are an important component of IPPD. IPPD builds on the concepts of design for manufacturing and concurrent engineering

History of Implementation

- Integrated product and process development (IPPD) was an extension of concurrent engineering. It included all business functions and technical areas in the design process.
- May 10, 1995: Secretary of Defense William Perry stated, "The concepts of IPPD and IPT shall be applied throughout the acquisition process to the maximum extent practicable."

Hypothesized Effect on Cost

- Engineering Change Orders: Using IPPD should greatly decrease the number of engineering change orders made in the production process—where they are most expensive.
- EMD: By having many people involved in the design phase, EMD may be more expensive.
- Production: Costs should decrease due to the consideration of manufacturing issues in the design stage.
- O&S: Costs should decrease due to the consideration of support issues in the design stage.

Benefits

Like Concurrent Engineering, IPPD is a systematic approach to the concurrent design of products and their associated processes. However, IPPD has expanded the teaming concept used in Concurrent Engineering to include representatives from nontechnical departments, the suppliers, the government, and the customers. These integrated product teams (IPTs) are an essential component of IPPD.

Caveats

The use of IPPD requires that more time and effort be spent in the design phase of a program. Thus, PDRR and EMD costs may actually increase due to the use of IPPD.

Results

IPPD has been successfully employed in government and commercial programs and is a requirement, where feasible, in government acquisitions.

What To Look For

- Whether there is a team, fully staffed with all required disciplines and design, production, operations and supports personnel, to carry out the IPPD.
- Whether the company has the experience and the design and planning tools to support the effort.
- Whether planning, cost estimating, and scheduling is carried out over the full life cycle of the product.
- Whether the benefits and savings of the IPPD can be related to specific savings in design, production, or support requirements, such as reductions in labor hours.
- Experience with IPTs.

6. Modeling and Simulation Versus Testing

The use of analytical models or computer simulation in lieu of traditional testing.

Interdependencies

Modeling and simulation is facilitated by computer-aided design. Virtual prototyping requires modeling and simulation. Modeling and simulation may result in reduced cycle time.

History of Implementation

- June 21, 1991: The Deputy Secretary of Defense issued a memorandum entitled "Modeling and Simulation Management Plan."
- July 22, 1991: The Under Secretary of Defense for Acquisition issued a memorandum entitled "Establishment of the Defense Modeling and Simulation Office."
- January 4, 1994: DoD issued DoD Directive 5000.59 establishing DoD policy for the management of modeling and simulation.

Hypothesized Effect on Cost

- Up-front investment may be required.
- System Test and Evaluation costs expected to decrease, as computer simulation replaces some testing.

Benefits

Utilizing computer simulation or modeling could lessen the need for potentially expensive testing.

Caveats

There is a cost associated with developing the models. Also, some testing may still be required to validate the model.

Results

Modeling and simulation have been widely and successfully applied in government and commercial programs.

What To Look For

- Appropriateness of modeling approach to system type.

- The specific areas where cost avoidance would be achieved, such as testing, design, redesign, and rapid prototyping. Also, the possibility of reuse of software, with cost spreading across a number of programs.
- Whether the company has prior experience in modeling and simulations and has the required tools and capabilities.
- Any up-front customization costs.
- Realistic projection of necessary testing program.

7. Virtual Prototyping

The use of a virtual prototype, in lieu of a physical prototype, for test and evaluation of specific characteristics of a candidate design. (A virtual prototype is a computer-based simulation of a system or subsystem with a degree of functional realism that is comparable to that of a physical prototype.)

Interdependencies

Virtual prototyping facilitates the integrated planning and teaming required in IPPD and IPTs by

- allowing visualization of data and three-dimensional drawings,
- enhancing the ability to test design changes on performance, test, evaluation, production, and support issues, and
- using a common virtual model that is available to all participants in the acquisition.

Virtual prototyping directly supports CAD/CAM initiatives and, in fact, can be thought of as an extension of CAD/CAM capabilities by the addition of functionality of the model and inclusion of a virtual environment.

Virtual prototyping supports the design assurance initiative, since that initiative requires rapid and on-going validation that the design meets the most current user requirements and that required changes have been introduced into the design before production.

Virtual prototyping facilitates the design for manufacture and assembly and the concurrent engineering initiatives by allowing simultaneous testing of numerous design alternatives. This engineering design and testing effort is faster and cheaper with the use of a virtual prototype.

Virtual prototyping facilitates modeling and simulation in testing by providing realistic, dimensionally accurate and functionally realistic virtual prototypes that can be used in test and evaluation.

History of Implementation

No information.

Hypothesized Effect on Cost

- Development Engineering and Prototype Manufacturing: Virtual prototyping may be significantly less expensive than developing a physical prototype for development and manufacturing—especially where extensive redesign and configuration changes are likely to require updated prototypes. However, in cases where the alternative is not to develop a prototype at all, additional design iterations may add to costs.

Benefits

There are several views of what virtual prototyping entails. At the lowest level of technical sophistication, virtual prototyping is considered to be only a computer-generated, dimensionally correct representation of a product, such as a system or component. At a higher level, the virtual prototype includes accurate functionality of the product. At an even higher level, the virtual prototype includes not only dimensional and functional representation, but also a virtual reality environment in which the user can experiment with and test the product. The cost and benefit considerations of the virtual prototype must be tailored to the purpose and level of sophistication of the model.

Virtual prototyping is applied in a wide range of applications in the acquisition process, including "engineering design concerns of the developer, process concerns of the manufacturer, logistical concerns of the maintainer, and training and doctrinal concerns of the warfighter."[20]

The most direct benefit of virtual prototyping is the avoidance of cost for developing physical prototypes, such as in concept validation early in the acquisition cycle. This benefit would be even greater where numerous redesigns are likely to occur, requiring multiple physical prototypes. Virtual prototyping can be considered for systems for which a physical prototype would be prohibitively expensive.

Virtual prototyping may provide much faster prototyping, shortening the design cycle and development process, and subsequently saving cost. Where a strategy of rapid prototyping is followed, virtual prototyping would support the faster production of physical prototypes. Faster prototyping and testing may also lead to improved product quality, and enhanced capability to address real-time, alternative-user scenarios.

Virtual prototyping software may be reusable, at least to some extent, on multiple programs, thereby allowing amortization of its cost over multiple products. Further, all parties may have functional access to the prototype at the same time for on-going analyses, such as government, contractor, and academia.

Caveats

The cost of developing and validating a virtual prototype may be substantial, especially as the prototype increases in sophistication and realism.

The virtual prototype may be highly unique to the product, with little opportunity either to reuse the software or to allocate its cost over multiple programs.

The use of virtual prototyping may lead to more prototyping and engineering analysis of design and manufacturing considerations rather than a reduction in cost. Therefore, it is not necessarily the case that the use of the virtual prototype, even though less expensive, would lead to a lower total cost. It would depend on the use of the virtual prototype in the program.

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[20] Defense Systems Management College, "Virtual Prototyping: Concept To Production," March 1994, p. 26.

Results

Sikorsky Aircraft carried out extensive virtual prototyping efforts on the demonstration and validation contract for the RAH-66 Comanche Helicopter. The Comanche Full Mission Simulation facility cost $25 million and was used to support design iterations of the crew station cockpit by evaluating the prototype in a realistic environment. It also was used in trade studies, human factor assessments of crew workload, verification and validation of flight control computer software and training. Virtual prototyping also supported use of concurrent engineering in the program, including development of the Sikorsky maintenance concept and the potential reuse of the virtual model in Sikorsky commercial programs. Sikorsky staff estimated that the use of 4,590 simulation hours in the crew station, integration, flight control, airworthiness, and training was equivalent to 11,590 flight test hours. According to Sikorsky, the company saved $673 million.

General Dynamics, Electric Boat Division, developed the Production Automated Design Process with the goals of reducing cycle time and cost, and improving product quality through integration of engineering design and manufacturing processes. The company creates a virtual prototype of a submarine. It is expected that the use of the virtual prototype will support concurrent engineering and a multidisciplinary design team, leading to fewer design iterations and a 30% reduction in design cost based on decreased cycle time. The virtual prototype is also much cheaper to build, resulting in direct cost avoidance.

Other examples include Boeing design of 777, and on-going projects at ARPA, NASA/AMES, TACOM-ARDEC, and other agencies.

What To Look For

- Contractor experience with the initiative; track record with past programs.
- The specific costs that would be avoided, such as avoidance of development of physical prototype or reuse of existing software and capabilities.
- Whether the company is experienced in the development and use of virtual prototypes and has the in-house software and hardware capabilities to support the effort.
- Involvement of subcontractors and requirers.

B. PRODUCTION AND SUPPORT INITIATIVES

1. Automated Test Equipment

The use of testing equipment that is capable of performing product testing with minimal operator involvement.

Interdependencies

The use of automated test equipment facilitates concurrent engineering and IPPD/IPT by allowing more rapid testing of design alternatives. In addition, the need to formally specify and program the performance test parameters into the automated test station forces the IPT to clarify and reach a decision upon design issues in a timely way. Automated testing is not an absolute requirement for those initiatives, but it does contribute directly to the ease and efficiency with which they can be carried out, since all three require extensive engineering design work and testing.

History of Implementation

No information.

Hypothesized Effect on Cost

- System Test and Evaluation: Automated test equipment could reduce this cost by reducing the cycle time for testing, by obtaining more consistent and accurate results, and by amortizing the equipment over several products.
- Training Services and Equipment: In-house automated testing may be less expensive than outsourcing the testing to the Original Equipment Manufacturers (OEMs), and it may provide more operationally realistic testing.

Benefits

Automated test equipment potentially provides benefits not only in the design phase of product development, but throughout the product's life cycle. Automated test equipment may yield more accurate and more consistent results, therefore requiring less testing to meet the test goals and product quality requirements.

It may also be less expensive than more labor-intensive, time-consuming alternatives. With modification, the equipment may be useful in testing numerous other products, allowing amortization of the costs over several product lines or projects.

Automated test equipment may provide faster testing, leading to a reduction in design cycle time and a more thorough testing program.

In the operational support phase of a product's life cycle, in-house automated testing may be significantly less expensive, and may offer a shorter turnaround time, than OEM testing. Further, the test station can be designed to reflect the operational environment, while OEM testing typically considers only the performance specification.

Caveats

The total cost of an automated test station includes not only an investment in equipment and training, but also the on-going costs of operation, testing, validation and recalibration of the equipment.

In order to provide a net cost savings, the initial fixed investment in automated testing equipment may require a substantial product volume over which the cost can be amortized. The product testing volume is likely to be larger when the testing equipment is used in operations and support testing than when used in design testing.

The use of an automated test station may reduce or eliminate the learning curve benefits that a company would obtain from a manual or partially automated testing process. However, this would not be a significant loss where fewer tests are required. Further, even in an automated system, learning curve benefits occur in terms of understanding the test procedure itself, such as how to deal with errors, system failures, recalibration of the system, and related issues. The learning curve losses are likely to be greater in operational and support testing than in design testing because of the greater potential volume of test products.

An automated test system may be unique to the equipment being tested, allowing for little or no amortization of costs over other products. Further, the automated system might require extensive redesign, test, and recalibration as changes in the product design and configuration are introduced.

Results

Warner Robins Air Logistics Center developed the Air Force Traveling Wave Tube (TWT) Automated Test Station as a way to test traveling wave tubes that had been reactivated/rejuvenated in a process developed by Rome Laboratory. The tubes are high-value products, ranging in cost from about $25,000 to well over $100,000 per tube. The Automated Test Station has been used to process several thousand tubes, many of which were used in Desert Storm. The Air Force indicates that it recovered the total system development cost, which was over $1 million, through the cost savings achieved by a single test station in its first year of operation at an Air Force depot. The savings are based on the reduction in in-house testing cost relative to sending the tubes to the OEM for testing. Further, the test station was able to test the tubes in the operational environment of the ALQ-131 electronic countermeasures system, while the OEM tested the tubes only according to the product specification. The automated test station eliminated the problem of having tubes fail operationally, only to be informed by the OEM that the tubes still tested accurately to specification. The operationally oriented testing provided greater confidence in the test results and contributed to improvement in mission capability.

The Army's TACOM-ARDEC Automated Testing Branch has successfully employed numerous automated testing systems for Army weapons, including Design for Testability implementation, Built-In-Self-Test development and evaluation, and Automatic Test Equipment development and support. The Automated Testing Branch supports many programs with automatic testing solutions, from product design through manufacturing and support.

What To Look For

The direct cost savings induced by automated test equipment can be estimated by considering several factors. First, the cost of the automated station, including the operation and maintenance cost, may be less than the cost of the manual or partially automated systems it would replace. Similarly, the automated equipment might be a less expensive solution than out-sourcing the testing to the OEM, such as in the case of operational testing. Second, part of the cost of the automated station may be amortized across other product lines if the station is not entirely unique to one product, providing additional savings. These cost comparisons can be made on the basis of projected cost build-ups and savings, in the same way an investment analysis of capital equipment is carried out.

The second type of cost savings is based on the potential reduction in cycle time for testing and on the possibility of less total testing being required, due to the improved accuracy and consistency of automated testing. However, these are second-order effects, not directly estimated from cost build-ups or equipment pricing. Further, although the automated testing is more accurate and could potentially be accomplished in a shorter testing cycle, the contractor could instead maintain the same level of testing, but provide an improved product. In this case, the benefit of the automated test station would not be a lower cost but a better product.

2. Computer-Aided Manufacturing (CAM)

Using a computer system to control and/or enhance the manufacturing process. Often coordinated with computer-aided design (CAD).

Interdependencies

Computer-Aided Manufacturing is often coordinated with computer-aided design and referred to as CAD/CAM.

A flexible manufacturing system usually utilizes computer-aided manufacturing.

CAM can be used to reduce manufacturing cycle time.

History of Implementation

- 1952: The Massachusetts Institute of Technology (MIT) held the first demonstration of a numerically controlled (NC) machine. This research was sponsored by the Air Force in order to develop more efficient manufacturing methods for modern aircraft.
- 1997: Computer-Aided Manufacturing was widely used and usually coordinated with computer-aided design (CAD/CAM).

Hypothesized Effect on Cost

- Nonrecurring EMD and Production: An initial investment cost is required to install a CAM system. However, a CAM system, especially when coordinated with CAD, can greatly reduce the time and cost required to go from product design to production.
- Recurring EMD and Production: CAM enables a production process to be performed more efficiently, and thus produces a higher quality product in less time and at less cost.

Benefits

The use of computer-aided manufacturing is hardly a new phenomenon. However, the integrated CAD/CAM systems being used today are far more advanced and sophisticated than their predecessors. They are more flexible and may be modular.

CAM can greatly improve the speed and efficiency of the manufacturing process. Likely tangible benefits include increased quality, reduced cycle time, less in-process inventory, and faster set-up times.

A computer-aided manufacturing system is most effective when coordinated with computer-aided design.

Caveats

By far the largest concern in implementing a CAM system is the large nonrecurring investment cost required. However, as with CAD, this system is usually flexible enough to be used for various projects. Also, there is often a lag time for a company to become proficient using a new CAD/CAM system.

Results

CADCAM Magazine (viewed online at http://www.cadcam-magazine.co.uk/) provides case studies of organizations using CAD/CAM technology.

What To Look For

Computer hardware (e.g., mainframes, client/server workstations, and personal computers) and software being used to provide operating instructions to machines in the manufacturing process.

The use of computer-aided design (CAD) and the coordination of the design process with manufacturing (i.e., the use of CAD/CAM).

3. Flexible Automated Manufacturing Process

A process in which the manufacturing equipment and machinery are capable of performing more than one task. The changeover between tasks should not require an unreasonably long lead-time.

Interdependencies

A flexible manufacturing system may be more effective if combined with a flexible work force.

History of Implementation

No information.

Hypothesized Effect on Costs

- Nonrecurring Production: A setup cost is required.
- Recurring Production: A flexible automated manufacturing process should increase efficiency and thus decrease recurring production costs.

Benefits

A flexible manufacturing system enables the use of automation for tasks that are done too infrequently to justify establishing an automated process. Also, a flexible manufacturing system can more easily adjust to sudden changes in demand. A flexible manufacturing system is especially useful for producing small lot sizes and for use on multiple products.

Caveats

A large initial nonrecurring cost is required to install a flexible manufacturing system. However, the system is normally flexible enough to be used for many processes and thus the cost can be amortized over several projects.

Results

Texas Instruments (TI) Defense Systems and Electronics Group installed a flexible manufacturing system in 1988. TI claims that use of this system resulted in 90% utilization and significantly reduced direct-labor hours.[21]

What To Look For

- Equipment capable of performing multiple tasks.
- Previous experience setting up machinery for different tasks.

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21 Department of the Navy, "Best Manufacturing Practices," November 1991.

- Very short set-up times.

4. Flexible Work Force

A system in which the labor force of a company is capable of performing multiple jobs depending on the current need. This may require labor-management agreements in unionized plants.

Interdependencies

Having a flexible work force is compatible with having a flexible manufacturing system.

History of Implementation

No information.

Hypothesized Effect on Cost

A flexible work force can reduce costs in all phases of the acquisition process.

Benefits

A flexible work force can yield several benefits. Product quality may improve from having cross-trained workers who are more familiar with the entire production process. Also, a flexible work force makes the company more agile. That is, the company is better able to react to changes such as sudden increases or decreases in demand or dramatic changes in the production process.

Caveats

There is a cost associated with cross-training workers. In a unionized plant, implementing a flexible work force may require a management-labor agreement.

Results

Lockheed Martin Electronics and Missiles implemented a flexible work force in an attempt to improve its competitive posture. Implementation entailed revising job classifications, cross-training workers, and developing a system to track employee abilities. Some claimed benefits include an increase in final inspection yield, the elimination of scrap, and a significant decrease in manufacturing costs.[22]

What To Look For

- A formal procedure for cross-training workers.
- A job classification system that stresses the skills required for each job and identifies the workers that are currently qualified.

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[22] Department of the Navy, "Best Manufacturing Practices," April 1995.

5. Just-in-Time (JIT) Manufacturing

A management principle that minimizes inventory by requiring that the level of supplies and equipment present exactly equals the amount required by the process.

Interdependencies

Implementation of just-in-time manufacturing requires that an excellent relationship exist between the contractor and the suppliers. Thus, vertical partnering and supplier certification aid in implementing just-in-time manufacturing. Also, JIT manufacturing often requires frequent orders and shipments of supplies and thus benefits from electronic commerce.

The concept of just-in-time manufacturing conflicts with multiyear procurement, in the sense that MYP as practiced in DoD involves paying up-front for supplies.

History of Implementation

No information.

Hypothesized Effect on Cost

- EMD and Production: JIT could decrease the costs in EMD and production associated with the holding of inventory. This may result in savings in nonrecurring production if less warehouse space is required. JIT may also result in savings in recurring production costs if the cycle time is reduced. JIT could cause production cost to increase if problems develop such as parts shortages or excessive breakdowns of segments of the production process.

Benefits

The goal of just-in-time manufacturing is to reduce inventory holding costs by having supplies delivered exactly when they are needed. The potential for savings is greatest in high-rate production where inventory holding costs can be substantial.

Caveats

In many cases, production of military products is done at such a low rate that just-in-time may not be applicable.

Most companies that implement JIT do not realize immediate cost savings. It is only after a long sustained effort that cost savings are realized.

Processes based on JIT manufacturing are greatly affected by sudden changes. Without excess inventory, a shortfall in a certain supply or a breakdown in a certain process could bring down the entire production process.

However, JIT manufacturing does make a company much more agile. It can respond better and faster to changing needs since there is only a minimal amount of inventory on hand.

Results

On October 3, 1997, Boeing announced that it was going to halt production of 747 aircraft for 20 work days and 737 aircraft for 25 workdays due in part to part shortages. The cost of this delay in production is estimated at about $2.6 billion.[23]

What To Look For

Methods for implementing JIT include:

- Using smaller and more frequent shipments of supplies. These shipments are scheduled to coincide as closely as possible with the time that they will be needed for production.
- Implementing pull manufacturing—where processes are not completed until they are demanded by a later process.

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23 Boeing Commercial Airplane Group, "Boeing Announces Aggressive Production Recovery Plan," News Release, October 3, 1997, and Tim Smart, "Boeing to Phase Out 2 Jetliners," *Wahsington Post*, Nov. 4, 1997, p. C-3.

6. Overhead Reductions

Measures taken to reduce the costs not directly associated with the design or production of a product. While overhead structures are different in each company, typical overhead functions include: facility maintenance, insurance, facility depreciation, and administrative expenses.

Interdependencies

- Essentially the same target as Simplification of Management Hierarchy.
- Can be implemented as part of continuous process improvement.
- Acquisition Reform can contribute by reducing reporting requirements.

History of Implementation

- 1960s-1970s: The United States lagged badly in productivity growth relative to the Japanese.
- Early 1980s: Faced with increasing global competition, US commercial manufacturing began quality improvements and searching for non–value-added activity.
- Late 1980s-early 1990s: US defense-oriented aerospace companies began implementing initiatives.
- 1995-1997: Activity-based costing was frequently used as a tool to identify non–value-added activity.

Hypothesized Effect on Cost

Overhead reduction can reduce cost in all phases, but especially in production. If the system is contractor-supported, overhead reductions will also show benefits in the O&S phase.

Benefits

Lower overhead costs.

Caveats

Recent mergers have been promoted on the basis that they will reduce overhead. Merged companies have the opportunity to eliminate excess facilities, including duplicative administrative systems and corporate offices. A General Accounting Office report indicates that overhead reduction is a major target of five large mergers.[24] A period of

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[24] General Accounting Office, "Defense Restructuring Costs: Information Pertaining to Five Business Combinations," April 1997.

adjustment is often necessary after a merger, in which overhead rates could actually increase. In a sole-source environment, there is less incentive to be efficient.

Costs may be transferred from overhead to direct in response to changes in DoD contracting practices.

Results

None available.

What To Look For

Consider total costs, not just overhead. The analyst needs to see evidence of total cost decrease, since costs can strategically be moved from overhead to direct. This is particularly true when there is more than one kind of system being produced in a given plant, with different contracting arrangements.

7. Reduced Cycle Time

Actions taken to decrease the amount of time required to perform a particular activity.

Interdependencies

- Computer-aided design/computer-aided manufacturing (CAD/CAM).
- Modeling and simulation (M&S).
- Virtual prototyping.
- Just-in-time manufacturing.
- Concurrent engineering.
- Integrated product and process development (IPPD).

History of Implementation

No information.

Hypothesized Effect on Cost

Cost savings in all phases of the acquisition process are likely to result from reducing the cycle time required for an activity or process.

Benefits

Significant savings can result from decreasing the cycle time required for an activity. By decreasing the time required for an activity, savings are likely in the costs of labor and work in process. Efforts to reduce cycle times are applicable to both EMD and Production.

In EMD, companies have attempted to reduce cycle times by eliminating certain tests. Modeling and simulation and CAD/CAM can aid in reducing cycle times in EMD. In Production, automation and just-in-time manufacturing have been used to reduce cycle times.

Caveats

There needs to be a method by which a company intends to reduce cycle times. Cost savings claimed due to reduced cycle times should be met with skepticism unless the company explains how they intend to reduce cycle times.

Government budgetary procedures may inhibit reducing cycle times. Significant reductions in production cycle times are likely to require increased expenditure. For example, consider a program that is scheduled to last 6 years and cost $60 million dollars. Suppose a company is able to reduce the cycle time of this program from 6 years to 3 years and for a total cost of $40 million. This will result in 33% savings ($40 million vs.

$60 million). However, it will require that $10 million more be spent in the first 3 years of the program ($40 million vs. $30 million).

Cycle time reductions to get the system to the user sooner may actually cost more, if the government is asking the contractor to add shifts or work faster than the technology will allow.

Results

There have been some successes in reducing the cycle time in the contracting area. The acquisition reform pilot programs report significant reductions in acquisition cycle times and program office staffing.[25]

What To Look For

- A specific plan as to how to reduce cycle times—as opposed to a generic statement or goal of reducing cycle times.
- A realistic reduction in cycle times. Examine the schedules that were achieved by similar programs.[26] Any claims of reducing cycle times well below the historical baselines should be met with skepticism.
- Some common methods that have been used to reduce cycle times include automation, modeling and simulation, concurrent engineering, integrated product and process development (IPPD), virtual prototyping, and the elimination of certain tests.

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25 Pilot Program Consulting Group 1996 Report.

26 Information on the schedules for previous programs can be found in M. B. Rothman, “Aerospace Weapon System Acquisition Milestones: A Data Base,” October 1987.

8. Supplier Certification

A process in which a company evaluates the performance of its suppliers and certifies suppliers as qualified. Often results in long-term relationships between contractors and suppliers.

Interdependencies

Supplier certification is very similar to vertical partnering. However, certified suppliers retain more freedom.

Supplier Certification enables some other initiatives such as just-in-time manufacturing, integrated product and process development (IPPD), and total quality management (TQM).

History of Implementation

- 1988: Texas Instruments initiated a supplier certification program.
- 1990: McDonnell Douglas Aerospace embarked on full-scale implementation of Preferred Supplier Certification.

Hypothesized Effect on Cost

- Nonrecurring and Recurring EMD and Production: The supplier certification process could lead to cost savings in the costs associated with getting supplies. These costs include not only the direct material costs, but also the costs associated with testing and with contractor oversight of the supplier processes.
  - Operating and Support: If the system is contractor-supported, supplier certification can reduce costs in this phase as well.

Benefits

It has been widely shown how a quality management effort can lead to substantial savings. The rationale is that it is much more effective to produce something right the first time than to perform extensive testing and have to deal with rejects and rework.

The supplier certification process attempts to extend this concept to receiving supplies. If a supplier is certified, then its quality management system is trusted to ensure quality. In addition, a supplier certification program can reduce the cost of contractor oversight of supplier operations.

Caveats

There are upfront costs associated with certifying suppliers. It takes additional labor from the company to evaluate and certify suppliers. Also, it takes effort for the supplier to meet all the requirements for certification.

In addition, it may take years before a supplier qualifies for certification. The benefits mentioned with supplier certification (e.g., improved quality and reduced inspection) result from the use of certified suppliers. Thus, very few benefits are likely to be realized until a company has a mature supplier certification procedure in place. Therefore, a program is not likely to realize savings if the company is just beginning a supplier certification program.

Results

Raytheon Missile Systems implemented a certified supplier program. In order to qualify for certification, suppliers must have a proven track record for quality, and on-time deliveries. Once certified, suppliers are able to ship their products to Raytheon stores with minimal inspection. Some of the claimed benefits of this program are improved quality, increased productivity, elimination of material returns, and a reduction in on-site inspection.[27]

A formal supplier certification program is used at Texas Instruments (TI), Defense Systems and Electronics Group. In this program, the supplier is primarily responsible for incoming quality. TI conducts statistical process control (SPC) training at the supplier’s facility and establishes the performance criteria necessary for certification. Once certified, suppliers receive preferential consideration from TI for new or follow-on work. The claimed benefits of this program include the reduction of redundant tests and inspections, and improvements in measurement techniques.[28]

Lockheed Martin, Government Electronic Systems, has a program in which suppliers can achieve three different levels of certification—Bronze, Silver, and Gold. Bronze certification requires 100% quality part rating, a minimum of six lots delivered, and an approved quality system. The Silver level requires an SPC program, a management letter of intent, and an on-site review. To receive Gold-level certification, the supplier must also have a continuous process improvement program. When certified, suppliers benefit from reduced surveillance and a preferred procurement status. Lockheed Martin claims many benefits from this program, including:

- 2.1% improvement in purchased material inspection yield,
- 67% reduction in lot backlog,
- 55% reduction in cycle time, and
- 87% reduction in scrap.[29]

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[27] Department of the Navy, “Best Manufacturing Practices,” August 26, 1991.

[28] Department of the Navy, “Best Manufacturing Practices,” November 1, 1991.

[29] Department of the Navy, “Best Manufacturing Practices,” October 16, 1995.

What To Look For

A formal written procedure clearly defining:

- the requirements for certification,
- the procedure to be used to test whether the requirements are met, and
- the benefits the suppliers receive after becoming certified.

9. Use of Commercial Components

The process of using existing products, technology, and software in the design and manufacture of a product.

Interdependencies

The use of commercial components is complementary to the acquisition initiative of performance-based specifications.

History of Implementation

- June 30, 1994: The Defense Science Board issued a report on acquiring defense software commercially.
- 1996 Defense Authorization Act: Contractors were no longer required to supply cost and pricing data on items already being sold commercially.

Hypothesized Effect on Cost

- Development Engineering and Engineering Planning: The most effective use of commercial components is likely to occur if early in the design process designers consider using commercial products. In this case, the development engineering and engineering planning may be more involved and thus more costly.
- Recurring Production: As a result of using commercial components where appropriate, savings are likely to be seen in the recurring production cost.
- Tooling: If certain parts can be purchased commercially, they do not need to be manufactured on a custom basis, and savings should result in tooling costs.

Benefits

The goal of using commercial products is to take advantage of existing commercial products and technology. Using commercial products is appropriate in situations where the commercial product satisfies the requirements and is of better quality or less expensive than its military counterpart. It allows the government to take advantage of the lower costs associated with higher volume and may reduce government administrative costs.

Using commercial products may reduce production and design costs. Also, using commercial products often results in shorter lead times and less in-process inventory. The greatest cost savings are likely to result if using commercial products is considered during the design phase.

Caveats

There are potential performance concerns associated with using commercial products. Products that do not meet military specifications may not be able to perform in some environments.

Many parts that are classified as commercial may lack a true market to determine their price. For these parts, the lack of cost data may lead to these parts being overpriced.

Commercial prices may include services such as customized delivery that the government does not need. Also, the government may be able to negotiate more favorable volume discounts than commercial customers receive.

Results

An audit by the Pentagon's Inspector General revealed that the prices on spare parts from Boeing for the 707 aircraft were significantly higher when purchased commercially.[30]

What To Look For

- The commercial experience of the company.
- Specific efforts in the design process to incorporate commercial components.
- Comparison of commercial prices with prices the government paid in the past for the same or similar items.
- Services included that government does not need.
- Company track record on reliability of parts.

30 *Defense News*, October 1997.

C. PROGRAM MANAGEMENT INITIATIVES

1. Activity-Based Costing (ABC)

An accounting system that first determines which processes and materials are consumed in creating a product, and then uses that knowledge to determine the product's cost. Where traditional systems allocate indirect costs with standard measures such as labor hours or machine hours, an activity-based system will create unique cost drivers designed to capture the resource utilization of each product.

Interdependencies

An effective ABC system is an important tool in implementing several cost initiatives because it provides insight into both the activities that create a product, and the cost of those activities. A clear understanding of the sources of cost is crucial to the success of design for manufacture, CAIV, and concurrent engineering efforts. Activity-based costing is also valuable in make/buy decisions, where a company's understanding of its costs will determine the quality of its decisions.

History of Implementation

Activity-based costing evolved during the 1980s.

Hypothesized Effect on Cost

ABC helps a company to better understand its true costs and thus promotes sound business decisions. The greatest impact is expected to be in the production phase.

Benefits

Unlike traditional cost systems, which were developed to meet financial reporting requirements, an activity-based system provides management insights into the costs of internal processes. A traditional system may treat the cost of a part as the cost of materials and the fully burdened cost of machining hours. In contrast, an ABC system might reveal the part's use of material receiving, material handling, machine setups, programming, drilling, finishing, and billing. In turn, each of these processes could have costs allocated to them by the processes and resources that they consume.

This understanding provides opportunities for cost reduction as well as cost accounting. Designers armed with a detailed knowledge of process costs can more effectively design the expensive processes out of their product. Industrial engineers attempting to reduce the costs of a product already in production can use the insights of an activity-based system to focus their efforts.

Caveats

Activity-based systems require much more information than traditional systems. The collection, storage, and synthesis of this information can entail a significant cost. Activity-based systems are unique to each product, and consequently, it is usually not clear at the outset what information should be collected. Companies often collect more information than they need, further increasing the cost of information.[31]

Effective activity-based systems require the participation of a large number of employees at all levels. This participation often requires a significant training expense. Like all initiatives, activity-based systems can also meet resistance from those generally opposed to change, as well as from employees who fear that their jobs will be eliminated during the process changes that activity-based systems can create.

Because of these hurdles, only an estimated 10% of the companies that attempt an activity-based system successfully implement and maintain one.[32]

Results

The Chrysler Corporation began implementing activity-based costing in 1991 in an extensive program that included training for 18,000 employees. Chrysler claims that the initiative produced hundreds of millions of dollars in benefits, or as much as 10 to 20 times the cost of implementation.[33]

Safety-Kleen, a waste recycling company, also began its activity-based system in 1991, and claims $12.7 million in benefits, or 14 times the cost of implementation.[34]

The City of Indianapolis used an ABC system to calculate the cost of its services so that it could evaluate outsourcing alternatives. Using the insights provided by activity-based costing, it then reduced the cost of its services and kept some services that it expected to outsource.[35]

What To Look For

A company that has implemented an ABC system should have a relatively small portion of its costs in overhead pools that are allocated by labor hours or machine hours.

If a company has out-sourced a significant number of processes and discovered

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31 Joseph A. Ness and Thomas Thurman, "Tapping the Full Potential of ABC," *Harvard Business Review*, July-August 1995.

32 *Ibid.*

33 *Ibid*.

34 *Ibid*.

35 City of Indianapolis, Marion County, 200 East Washington Street, City-County Building, *The Indianapolis Experience, Part I, Chapter IV,* "Case Study #1: Activity-Based Costing" [Online] (1997), Available: http://www.ci.indianapolis.in.us/comp/indyexp/part1/chapter4/activity.html [December 29, 1997].

that the remaining processes have become more expensive, it may be an indication that ABC costing is not being implemented, or that it is being implemented improperly. A company's inability to compete on cost, even on processes for which it should have a comparative advantage, is also an indication of an ineffective cost-allocation system.

2. Continuous Process Improvement (CPI)

The commitment of resources to improving organizational processes, including management, engineering, production, and support. These processes are continuously scrutinized for improvements.

Interdependencies

Continuous process improvement is an important element in any total quality management (TQM) program.

History of Implementation

- March 30, 1988: The Secretary of Defense issued a memorandum entitled "Department of Defense posture on quality—the TQM initiative."
- June 1988: The Federal Quality Institute was established to introduce executives in government to TQM concepts and benefits.
- August 19, 1988: The Under Secretary of Defense (Acquisition) issued a memorandum entitled "Implementation of TQM in DoD acquisition."

Hypothesized Effect on Cost

- Engineering Planning: Costs early in the program are likely to increase due to the extra effort involved in continuously examining the process.
- Production: Production should be more efficient and less costly as a result of the improvements made to the process.
- O&S: O&S costs may be lower depending on the support process established.

Benefits

CPI is a major component of any TQM effort. The purpose of continuous process improvement is to constantly reexamine the entire process to find ways of doing things better and cheaper.

Caveats

CPI is most useful for repeated or generic processes since any improvements in these processes can result in real savings. As with TQM, continuous process improvement is most effective in companies with a history of implementing CPI and an ability to readily implement process improvements.

Results

The Navy F-14 overhaul program credits the implementation of continuous process improvement with reducing its average overhaul cost from $1.6 to $1.2 million per aircraft.

During the late 1970s and the early 1980s, Xerox lost 50% of its market share worldwide. To combat this trend and to compete with the Japanese, Xerox implemented a continuous improvement process. By 1985, Xerox had cut development cost, development schedule, and manufacturing costs in half and had begun to regain market share.[36]

In the early 1980s, the General Motors (GM)-Toyota Fremont plant implemented Japanese-style management, including continuous process improvement. This plant experienced productivity levels 50% greater than any other GM plant.[37]

What To Look For

- A formal procedure for evaluating the entire organizational process. This includes a commitment of personnel to examine the processes and a procedure to implement improvements.
- Corporate experience with CPI is important since it normally takes a few years before benefits are realized.

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[36] Gary Jacobson and John Hillkirk, *Xerox: American Samurai,* MacMillan Publishing Company, 1986.

[37] J. Richard Nelson, James Bui, John J. Cloos, and David R. Graham, "Management Practices To Achieve More Affordable NASA Programs," Document D-1297, Institute for Defense Analyses, June 1993.

3. Electronic Commerce/Electronic Data Interchange (EC/EDI)

Electronic commerce is the paperless exchange of business information using electronic data interchange, electronic mail, computer bulletin boards, facsimiles, electronic funds transfer, and other similar techniques. EDI is the computer-to-computer exchange of business information using a public standard (e.g., ANSI X12 or EDIFACT).

Interdependencies

By allowing orders to be filled more efficiently, EDI is a key element in implementing just-in-time (JIT) manufacturing. Also, by providing information faster and more accurately, EDI aids in implementing a total quality management (TQM) program.

History of Implementation

- 1975: The transportation industry developed and used EDI for the first time.
- May 24, 1988: DoD mandated EDI use for all DoD business-related transactions.
- October 26, 1993: The president issued a memorandum implementing the electronic commerce initiative with the objective of ensuring that electronic commerce is implemented for appropriate federal purchases.
- October 13, 1994: The Federal Acquisition Streamlining Act established a government-wide Federal Acquisition Computer Network (FACNET) and required the acquisition process be based on EDI.
- June 23, 1995: DoD expanded the EDI mandate to include all DoD functional areas.

Hypothesized Effect on Cost

A setup cost is required to implement EC/EDI. EC/EDI should lead to lower costs in Engineering and Manufacturing Development, Production, and O&S due to quicker and more accurate information-sharing and efficiencies in ordering.

Benefits

EC/EDI allows information to be shared faster, cheaper, and more accurately then a paper-based system. Electronic commerce can help reduce the cycle time in a contracting process. It can also lead to more bidders, and thus, more competition.

Caveats

A setup cost is required to implement EDI. Also, no standard format exists for implementing EDI—although the government is trying to establish a standard (ANSI X12) for all government agencies. Until a standard format is widely adopted, compatibility problems may keep companies from realizing all of the potential benefits of EDI.

Results

None available.

What To Look For

- A manufacturing facility where few, if any, communication tasks are performed using paper. Some typical areas where electronic commerce is used are contracting, reporting, ordering, billing, and manufacturing. Also, the government agencies need to be set up to use EC/EDI.

4. Integrated Product Teams (IPTs)

Groups of specialists from different areas and organizations that are assembled to address specific tasks. The team can be firm-specific, cross-firm, or government-industry.

Interdependencies

IPTs are the main tool in implementing integrated product and process development (IPPD). Vertical Partnering is an initiative that includes suppliers on IPTs. IPTs are also a key ingredient in using cost as an independent variable (CAIV).

History of Implementation

- 1985: Boeing Aerospace implemented the Product Development Team (PDT) initiative.
- April 28, 1995: The Under Secretary of Defense (Acquisition and Technology) issued a memorandum stating, "We must move away from a pattern of hierarchical decision making to a process where decisions are made across organizational structures by integrated product teams."
- May 10, 1995: Secretary of Defense William Perry issued a memorandum stating, "The concepts of IPPD and IPT shall be applied throughout the acquisition process to the maximum extent practicable."
- 1997: The use of IPTs became mandatory for all Acquisition Category (ACAT) I programs.

Hypothesized Effect on Cost

- EMD: Using IPTs requires an increase in effort early in the product life cycle and thus EMD costs are likely to increase as a result.
- Production: Production should be more efficient and less costly as a result of the increased effort during the design phase.
- Engineering Change Orders: Employing an IPT will likely cause an increase in engineering change orders early in the design process (when they are least expensive) and a decrease in engineering change orders during production (when they are significantly more expensive). Overall, the cost of engineering change orders should decrease.
- O&S: Costs should decrease, depending on the support process established.

Benefits

IPTs are the primary method by which integrated product and process development (IPPD) is implemented. Using IPTs should yield benefits in producibility and the coordination between the product design and production requirements. An IPT is most effective if it is formed early in the product life cycle and the team has the ability to influence the design, cost, and requirements for the product.

Caveats

A cost is incurred by having the team members involved early in the product life cycle. Also, additional training is required so that the members of an IPT understand the purpose of their team and the ways in which their team can be most effective.

Results

On March 7, 1996, the F/A-18E/F program received a DoD Acquisition Excellence Award. The use of Navy/Industry integrated product teams was cited as one of the factors that contributed to the success of the program.[38] McDonnell Douglas Vice President Mike Sears claims that these IPTs were a key element in maintaining the cost and schedule of the aircraft.[39]

What To Look For

- The creation of a multidiscipline team or teams early in the program. Each IPT should have a specific objective and must be empowered to make decisions to meet this objective.

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38 "F/A-18E/F Receives DoD Acquisition Excellence Award," *PR Newswire*, p. 308, March 8, 1996.

39 Stanley W. Kandebo, "New Hornet Rolls Out on Time, Within Budget" *Aviation Week & Space Technology*, vol. 143, no. 13, September 25, 1995, p. 90.

5. Make/Buy Out-Sourcing

The process of deciding whether to manufacture a component or assembly within the organization or subcontract the work to an external vendor.

Interdependencies

- Overhead reductions.
- Supplier certification.
- Vertical partnering.
- Activity-based costing.

History of Implementation

In the F-16 program, Lockheed Martin used out-sourcing extensively—especially late in the production run.

Hypothesized Effect on Cost

Production costs will be lower if out-sourcing is used to send work to more efficient producers.

Benefits

Make/buy out-sourcing decisions can reduce costs by sending work to more efficient producers.

Caveats

Excessive out-sourcing could lead to labor problems in unionized plants. Also, vertically integrated companies have an incentive to direct business in-house in a sole-source environment.

Out-sourcing could cause overhead rates to increase, because fixed overhead can be allocated to fewer activities.

Results

No information.

What To Look For

- A thorough accounting for the direct costs and associated indirect costs (such as the effect on overhead) of make/buy decisions.

6. Simplification of Management Hierarchy

A reduction in the number of management personnel or the number of levels in the management structure. Rationale is overhead and direct cost reduction through the elimination of non–value-added activity.

Interdependencies

- Essentially the same target as Overhead Reduction.
- May be implemented as part of continuous process improvement.
- Complementary with integrated product teams (empowered team members need less management).
- Activity-based costing is frequently used as a tool to identify non–value-added activity.

History of Implementation

- 1960s-1970s: The United States lagged badly in productivity growth relative to the Japanese.
- Early 1980s: Faced with increasing global competition, US commercial manufacturing began quality improvements and searching for non–value-added activity.
- Late 1980s-early 1990s: US defense-oriented aerospace companies began implementing initiatives.

Hypothesized Effect on Cost

- Nonrecurring EMD and Production: These costs should be lower due to fewer personnel.
- Overhead Costs: To the extent that managers perform overhead functions, overhead costs that are allocated to all other costs can be expected to decrease.

Benefits

Simplifying the management hierarchy may lead to savings in the indirect cost of management personnel.

Caveats

May make it more difficult to implement other initiatives, due to lack of management resources and lack of continuity.

Results

None available.

What To Look For

- Changes in headcounts.

7. Total Quality Management (TQM)

A fundamental rule or belief for operating an organization aimed at continually improving performance over the long term with a focus on processes and the use of process action teams.

Interdependencies

Total quality management is a total commitment from an organization to quality. Components of TQM include:

- continuous process improvement,
- supplier certification and vertical partnering, and
- concurrent engineering and integrated product and process development.

History of Implementation

- March 30, 1988: Secretary of Defense issued a memorandum entitled "Department of Defense posture on quality—the TQM initiative."
- June 1988: The Federal Quality Institute was established to introduce executives in government to TQM concepts and benefits.
- August 19, 1988: The Under Secretary of Defense (Acquisition) issued a memorandum entitled "Implementation of TQM in DoD Acquisition."

The Naval Air Systems Command coined the term "Total Quality Management" to describe the Japanese-style management approach to quality improvement. TQM builds on the quality assurance work of Deming and describes the requirements to achieve world-class quality.

Hypothesized Effect on Cost

- Development Engineering and Engineering Planning: Likely to be more costly due to increased management effort early in the product's life cycle.
- Production and EMD: TQM should lead to a higher-quality product and lower production and support costs.

Benefits

Companies in many different industries have implemented the Japanese management approach to quality, which has come to be known as total quality management.

Companies that have successfully implemented TQM have seen reductions in scrap and rework, increases in quality, and decreases in total cost.

Caveats

TQM is most successful in companies with a history of quality and continuous process improvement. Implementing TQM may conflict with the culture of certain companies.

Results

See examples in discussion of continuous process improvement (CPI) and integrated product and process development (IPPD).

What To Look For

See examples in discussion of CPI.

8. Vertical Partnering

The teaming up of a contractor with a customer, subcontractor, or supplier. Often involves sharing technology and forming IPTs.

Interdependencies

- The teaming of a contractor with its subcontractors facilitates the implementation of many other initiatives (e.g., just-in-time manufacturing and total quality management).
- Vertical partnering is similar to supplier certification. Both attempt to improve the procedure for getting supplies.
- Mergers and acquisitions can reduce the likelihood of vertical partnering by creating more possibilities for using in-house suppliers.

History of Implementation

- 1988: Texas Instruments (TI) implemented vertical partnering, referred to as Team Enhancement and Management Strategy (TEAMS). As a part of this initiative, TI conducted 2-day workshops for management personnel of new suppliers.

Hypothesized Effect on Cost

- Contractor EMD: Costs should be lower due to teaming arrangements.
- Recurring Production: Costs should be lower due to teaming arrangements.
- O&S: Costs should be lower lower due to teaming arrangements.

Benefits

Vertical partnering is an attempt to improve the efficiency of the relationship of the contractor with the subcontractors and suppliers. Improving these relationships will likely result in more reliable deliveries, fewer compatibility problems, and improved product quality.

Caveats

A danger of vertical partnering is that companies may give undue preferences to subcontractors and supplies with which they have formed partnerships. This practice would result in less competition and higher prices.

Results

No information.

What To Look For

- Formal teaming agreements between a contractor and its suppliers.
- Communication such as sharing technology and joint involvement on integrated product teams.

D. GOVERNMENT ACQUISITION INITIATIVES

1. Commercial Standards

Having production adhere to commercial industry standards as opposed to requiring military-unique specifications and standards.

Interdependencies

- Facilitates modeling and simulation versus testing.
- Facilitates use of commercial components.
- Similar to performance-based specifications.
- Related to single process initiative, which encourages replacement of multiple, government-unique management and manufacturing systems with common, facility-wide systems.[40]

History of Implementation

- 1987: The International Standards Organization (ISO) published the ISO 9000 standard series on quality management and quality assurance.
- February 14, 1994: Deputy Secretary of Defense John Deutch authorized programs to use American National Standards Institute/American Society for Quality Control (ANSI/ASQC) Q90 and ISO 9000 series model quality standards for new programs. Programs were also allowed to use those standards for follow-on efforts for existing programs instead of MIL-Q-9858A, Quality Program Requirements, and MIL-I-45208A, Inspection System Requirements.
- June 29, 1994: Secretary of Defense William Perry directed the military services "to use performance and commercial specifications and standards instead of military specifications and standards, unless no practical alternative exists to meet the needs of the users."
- March 1996: The Aerospace Industries Association established an early warning project to maintain needed standards.
- June 1996: The Office of the Under Secretary of Defense for Acquisition and Technology/Acquisition Practices issued "MilSpec Reform: Results of the First Two Years," which reported that management- and process-type military standards "have been canceled, converted to guidance handbooks, or in a few cases, replaced with commercial standards." The paper also reported, "In April 1996, the Department of Defense and Texas Instruments Defense

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40 Under Secretary of Defense (Acquisition and Technology), "Single Process Initiative," policy memorandum, December 8, 1995.

Systems and Electronics Group struck an agreement to allow Texas Instruments to become the first US defense contractor to institute a common set of manufacturing standards for all of its products. This change will allow Texas Instruments to eliminate about 35,000 pounds of hazardous chemicals used in painting each year." It also will allow use of commercial practices on a single production line that makes weapons for the different DoD components.

Hypothesized Effect on Cost

- Production: Expected to decrease after a transition period.
- Development Engineering: Expected to decrease.
- Government Development and Production: Project management, expected to decrease.

Benefits

Allowing for commercial standards permits the use of more cost-effective manufacturing processes and takes advantage of industrial technology.

Use of commercial standards allows factories to produce military and commercial products using the same management and manufacturing processes. It may facilitate the diversification into commercial markets of firms that have traditionally produced goods primarily, if not solely, for DoD.

Caveats

Commercial components may not meet the performance requirement in the military operating environment in the electronics area. (In other areas, commercial specifications and military specifications evolved together and are generally the same.)

Military-specific vendors who are set up to comply with military specifications may incur substantial costs to have their systems commercially certified. There may be other transition costs as well. For example, if there are no relevant commercial specifications, industry may try to charge the government to develop a standard.

Results

Many programs have reduced specifications and projected cost savings or cost avoidance.

Lockheed Martin attempted to charge the government for developing specifications for use in the THAAD program.

What To Look For

- No unnecessary standards.
- High degree of involvement by requirers.
- Contractor experience; track record on past programs.

2. Cost As an Independent Variable (CAIV)

The process of considering an aggressive cost target along with performance and schedule targets and making trade-offs among these objectives.

Interdependencies

The use of IPPD and IPT, the procurement price commitment curve, performance-based specifications, and aggressive price targets are common in CAIV programs. CAIV programs also tend to use streamlined acquisition procedures, with minimal military specifications and Contract Data Requirements Lists (CDRLs).

History of Implementation

- July 19, 1995: Under Secretary of Defense Paul Kaminski issued a memorandum stating "I am committed to establishing a process whereby cost is an independent variable in programmatic decisions, and cost goals are set in each program phase." At that time, CAIV was adopted for all ACAT ID programs. Since then, the military services have designated eight Flagship Programs to serve as role models for implementation. These include Army Tactical Missile System/Brilliant Anti-Tank (ATACMS BAT) submunition, CRUSADER Advanced Field Artillery System, Air-to-Air Intercept Missile (AIM-9X), Multifunctional Information Distribution System (MIDS), Space Based Infrared System (SBIRS), Joint Air-to-Surface Standoff Missile (JASSM), Evolved Expendable Launch Vehicle (EELV), and Joint Strike Fighter (JSF).
- Mid-1990s: The Joint Direct Attack Munition (JDAM) traded off commonality with the Joint Standoff Weapon's guidance unit to reduce costs. The program also made many cost-performance trades during Phase I of EMD, with the full involvement of the operational user.
- June 1994: MIDS, a Flagship Program, completed a 6-month effort to redesign its terminal based on cost reduction and performance trade initiatives.
- 1995-present: AIM-9X, a Flagship Program, used the following techniques as part of its CAIV initiative: IPPD processes, a minimum requirement using key performance parameters (KPPs), cost-performance trades, aggressive price targets, procurement price commitment curve.[41]

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[41] Navy Acquisition Reform Office, *Change through Ex-Change: Innovation*, [Online] (March 17, 1997), Available: http://www.acq-ref.navy.mil/pdf/innovati.pdf [January 13, 1998].

Hypothesized Effect on Cost

- PDR and EMD Contractor: Expected to increase due to involvement of manufacturing and support personnel, engineering to make cost-performance trades.
- PDR and EMD Government: Expected to increase due to increased involvement of the requirements community.
- Engineering Change Orders: Expected to decrease in production due to early trades.
- Contractor Production: Expected to decrease due to earlier system definition and cost-performance trades.
- Contractor Program-Level: Expected to decrease due to earlier system definition and partnership with government in integrated product teams (IPTs).
- Government Production: Expected to decrease due to earlier system definition.

Benefits

Lower procurement costs are expected than with non-CAIV programs due to the use of an aggressive price target and cost-performance trades.

Using CAIV should reduce gold plating and provide usable systems sooner.

Logistics support costs should be lower due to early planning and system definition. Many CAIV systems provide for long-term warranties.

Caveats

The magnitude of savings will depend on the relative priority given to the cost objective.

Government must give up some design flexibility in the later stages of the program for CAIV to work.

Aggressive price targets may be accepted in order to keep the program going. They may create unrealistic expectations and leave programs underfunded.

Results

The AIM-9X program turned $117 million of RDT&E funds back to DoD and got back $75 million in procurement, facilitating an initial operational capability a year earlier than the previous baseline.[42]

The MIDS program employed a program manager's Tradespace model to avoid

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42 *Ibid.*

spending $434,684 in functional improvements not supported through customer input.[43] MIDS reports that end-user appreciation of costs (and opportunity costs) is critical in supporting tradeoffs.

The F/A-18E/F program removed some radar-absorbing material when test results showed that the extra material was not required to meet specifications.[44]

CAIV programs are insufficiently mature to exhibit *actual* procurement cost savings at this point. The JDAM program, an early implementation of CAIV, is currently being worked to meet its operational requirement. The EMD contract is exhibiting cost growth. It began at $72 million and is now at $77 million. Estimate at completion (as of January 1998) is $95 million. The production decision is being set back a year, from April 98 to April 99. However, production costs may not rise significantly.

What To Look For

- Early cost-performance trades, with warfighter involvement.
- Aggressive price target, with recognition of risks.
- Implementation of IPPD, with government-contractor-supplier partnerships in IPTs.
- Regular exchange of data among all parties.

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43 *Ibid.*

44 Stanley W. Kandebo, "New Hornet Rolls Out on Time, Within Budget" *Aviation Week & Space Technology*, vol. 143, no. 13, September 25, 1995, p. 90.

3. Contract Incentives

Contract provisions designed to induce desired contractor behavior through the use of higher fees. Types include incentive fee or award fee, and contracts can be cost plus or fixed-price. Incentive fees are typically tied to cost performance. Award fees are broader and can target a variety of goals, including delivery dates or reliability and maintainability.

Interdependencies

May be used to encourage implementation of other initiatives. For example, incentive fee or award fee contracts can be used to encourage overhead reductions or CAIV. If dual-source competition is not possible, incentive contracting can encourage cost-reducing behavior.

History of Implementation

The early 1960s was an "incentive era" in which the government used a lot of incentive contracts.

Hypothesized Effect on Cost

Cost effects depend on the specific type and phase of the incentive.

Benefits

- Cost savings compared with what costs would be in fixed-fee contracts.
- Desired contractor behavior.

Caveats

Incentive contracts may be more expensive to administer. In particular, award fee contracts may have higher administrative costs, because of the necessity of measuring and monitoring contractor performance.

Results

The General Accounting Office (GAO) reviewed 62 fixed-price incentive contracts from 1977 to 1984 to determine how the final price of each compared with the contract's established target and ceiling prices. GAO found that the final prices on 58% of the contracts were within 5% of the target, and 92% were within 10% of the target. However, contract costs and price seemed unrelated to the sharing ratio.[45]

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[45] Some of the contracts were relatively small; however, 56 of the contracts were for over $1 million, and 22 were for over $10 million each. See US General Accounting Office, "Incentive Contracts: Examination of Fixed-Price Incentive Contracts," GAO/NSIAD-88-36BR, November 1987.

What To Look For

- Exact contract provisions, including sharing ratios.
- Past performance.

4. Dual-Source Competition

Use of more than one source in production. Multiple sources are usually carried over from development. In some cases, a second source has been developed after several lots of sole-source production.

Interdependencies

Dual-source competition can encourage industry to implement other cost-reduction initiatives.

Multiyear procurement can be useful for a sole-source buyout at the end of the program.

History of Implementation

- 1981: Increased competition was one of the Carlucci initiatives.
- 1986: The Packard Commission recommended commercial-style competition.
- 1984: The Defense Appropriations Act required a competition plan unless quantities were insufficient.
- 1984: Competition in Contract Act required competition as the norm and provided for competition advocates in the services.

Hypothesized Effect on Cost

- EMD Contractor: Likely to increase—multiple prototypes, more cost to do multiple detailed designs—tooling, equipment, qualification, and administration to establish a second source.
- Contractor Production: Net cost may decrease or increase—increases due to lack of economies of scale in nonrecurring production, more system test and evaluation, decreased cost due to contractor motivation to reduce costs to win the bid. This manifests itself through shift or rotation of the learning curve.[46]
- O&S: Support costs may increase due to the need to maintain two versions of the system.

Benefits

- Reduced prices due to competitive pressures.
- Increased contractor responsiveness to government needs.
- Enhanced system quality and reliability. (Several competitive programs, such

46 L. A. Kratz, J. W. Drinnon, and J. R. Hiller, "Establishing Competitive Production Sources: A Handbook for Program Managers," ANADAC, Incorporated, August 1984.

as Tomahawk and the alternative fighter engine, were motivated more by quality considerations than by cost.)

- Enhanced industrial base for future competitions.
- At the end of the production run, a multiyear buyout to a single contractor can generate an attractive price.

Caveats

Up-front costs increase. In evaluating competition, we need to use an investment model to determine whether benefits outweigh costs.

When developing a second source during production, technology transfer can be challenging and costly. Under this “leader-follower” model, the leader has a disincentive to provide a clear, comprehensive, and accurate technical data package to the follower.

Contractors can be squeezed so hard that they experience financial problems and have a hard time delivering. (Pennsylvania Shipbuilding went bankrupt and shut down during the TAO-187 program. However, the Naval Center for Cost Analysis determined that the competition still saved the government money.)

Results may vary with capacity utilization in the industry, with the best outcomes when there is excess capacity.

Full benefits of learning and high-rate production are not realized. The rate of production may be as significant as the cumulative quantity factor in determining average lot prices. Large buys typically exhibit lower unit costs than small buys, other things being equal.

Funding stability is crucial to the success of competition. When there are cutbacks in quantity, as in the AMRAAM program, production costs grow.

Results

Government successfully exploited overcapacity in the shipbuilding industry to get favorable prices on ships in the 1980s.

It is easier to find savings in prices than in resource inputs. Thus, savings from dual sourcing seem to come either from profits or from the prices for inputs.[47]

Dual sourced programs tend to buy more quantity than planned over a longer period of time than planned (example: AIM-7F). Some benefits may accrue due to program stability rather than to competition.

The Naval Center for Cost Analysis examined twelve dual-sourced programs in 1989 and found that all twelve programs had some net savings. Savings ranged from 0.8%

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47 Karen W. Tyson, Neang I. Om, D. Calvin Gogerty, J. Richard Nelson, and Daniel M. Utech, “The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs,” Paper P-2722, 2 volumes, Institute for Defense Analyses, November 1992.

to 27.9%, with an average of 14.2%.[48]

What To Look For

- Excess capacity in industry.
- Large enough buy (both in total and per lot) to make competition worthwhile. Likelihood of future funding stability to procure at full rate.
- Specific learning curve differences hypothesized.
- Timing of the competition. The later in the life cycle the competition occurs, the more likely the system is to be mature, without substantial modifications that might decrease benefits. However, at the same time, a late competition means fewer units over which to capture savings.
- A solid technology transfer plan, if competition is a leader-follower type. Reasonable estimate of cost of technical data package.

48 Brian Flynn and Dennis Herrin, "Results of Competitive Procurement in the 1980s," Naval Center for Cost Analysis, December 1989.

5. Multiyear Procurement (MYP)

Contracting for more than a single year's buy in a single contract, as an alternative to a series of annual contracts. Through economic quantity buys, MYP is expected to reduce the cost of procuring a weapon system.

Interdependencies

MYP conflicts with just-in-time management, because large quantities of materials or components are bought up front.

MYP encourages vertical teaming to get minimum prices and to manage delivery.

History of Implementation

- 1960s: DoD used MYP extensively. The Army pioneered with small automotive motors.
- 1973: The FY 1973 Defense Authorization Act established a maximum cancellation ceiling of $5 million. This virtually eliminated the use of MYP on major system acquisitions.
- 1982: FY 1982 legislation set guidelines for congressional approval. They include stable requirements, design, and funding, and confidence in the production cost estimate. The General Accounting Office (GAO) assessed the extent to which programs applying for MYP meet the congressional guidelines. Appropriations acts in each year set the terms for implementation of MYP by individual programs.
- 1983: A Defense Science Board study said that MYP could save program costs, and expanded use of MYP was adopted as one of the "Carlucci initiatives."
- 1994: Federal Acquisition Streamlining Act gave the Secretary of Defense authority to authorize MYP, although Congress still had to provide funding commitment.
- In recent years, MYP has been seldom used. The C-17 cargo aircraft program is the largest current implementation.

Hypothesized Effect on Cost

- PDR and EMD: Higher cost due to advanced funding possible.
- Nonrecurring Production: Advanced funding of material and components from subcontractors and vendors, lower prices from subcontractors and vendors due to economic quantity buys.
- Recurring Production: Exploit economics of scale, schedule production efficiently, allow specialization within or across plants.
- Government and Contractor System Engineering/Program Management:

Lower costs for contract development and management.

Benefits

MYP provides funding stability, which usually results in fewer unplanned cost and schedule changes.

Typically, the majority of savings in a multiyear arrangement comes from the ability to procure subcontractor and vendor items more economically.

Manufacturing savings may also be achieved due to stable production rates.

Caveats

Startup costs include funding for advance procurement and economic order quantities. While the Army has done MYP with minimal up-front cost, the typical implementation requires considerable up-front funding.

MYP flies in the face of the "lean manufacturing" philosophy to minimize inventories. The firm is buying a lot of inventory in the hopes of lowering the price. Lean manufacturing philosophy says that inventory is evil, not just because it costs money to buy. Inventory requires "management, shelter, movement, control, accounting, putting in storage, removal from storage, protection." Moreover, inventory allows the firm to run a defective production system. Extra parts keep assembly lines going even when preceding processes are defective and provide an alternative to solving fundamental production problems.[49] One way a firm can alleviate some of these difficulties is to contract to buy large quantities, but to schedule just-in-time delivery.

Multiyear contracts carry a cancellation fee. Quantity reductions would be penalized.

Multiyear procurement can cost the government money if the design is not stable. Changes may be difficult to incorporate once commitments to vendors are made.

MYP may reduce the funding available for other acquisition programs. The military services' flexibility to revise priorities among their programs and to reallocate funding is reduced by MYP.

Results

The F-16 fighter program is often cited as a good application of MYP.

What To Look For

- Stability of requirement, design, and funding.
- High confidence in cost estimate.
- High priority of program relative to others.

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49 Fred Stahl, *Lean Production Systems and Global Competitiveness*, Boeing pamphlet, August 1997.

6. Performance-Based Specifications

Specifications that describe the performance requirements of a product rather than its detailed physical or technical characteristics. The contractor is allowed to determine how these performance requirements are met.

Interdependencies

Use of performance-based specifications encourages CAIV by creating more options for cost-performance tradeoffs. It also enables the use of commercial components as technically appropriate.

History of Implementation

- June 29, 1994: Secretary of Defense William Perry directed the military services "to use performance and commercial specifications and standards instead of military specifications and standards, unless no practical alternative exists to meet the needs of the users."
- 1995-present: Sparrow missile used performance drawings for the circuit card level and below for the guidance and control system.[50]

Hypothesized Effect on Cost

- Development Engineering and Engineering Planning: May increase due to the need to explore different options to meet the performance objective rather than following a prescribed path. May decrease due to greater freedom to explore design options.
- Recurring Production: Expected to decrease, as industry chooses the most efficient design.

Benefits

- Reduced costs due to contractor's ability to optimize component selection.
- Reduced time and expense of qualifying new parts.
- Reduced cycle time.
- If warranty is provided, contractor assumes some of the risk associated with performance.

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50 Navy Acquisition Reform Office, *Change through Ex-Change: Innovation*, [Online] (March 17, 1997), Available: http://www.acq-ref.navy.mil/pdf/innovati.pdf [January 13, 1998].

Caveats

The government becomes dependent on a single source of supply for maintenance and repair.

To compensate for loss of control of requirements in lower tiers, the government can require the contractor to provide a warranty. (Standard Missile 2 Block IIIB program.)[51]

Results

Government gives up some lower-level visibility in performance drawings, according to Sparrow missile experience. This means that the government must make sure that performance requirements are well documented at the top level.

What To Look For

- Clear documentation of performance requirements.
- High degree of involvement by requirers.
- Warranty or other support plan.

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51 *Ibid.*

E. CORPORATE POLICY

1. Corporate Program Investment

A corporate commitment to bear all or part of the cost of an initiative or a program, in order to keep the program affordable. The funds expended by the company are sometimes referred to as a "management contribution."

Interdependencies

A variety of initiatives can be financed by corporate investment.

The contractor may share in the gains through incentive contracting.

History of Implementation

This is a common initiative. A recent example is Lockheed Martin's F-22 Producibility Improvement Program. The company is making an investment in the hopes of reducing the cost of the 339-aircraft program substantially.

Hypothesized Effect on Cost

- Contractor PDRR and EMD: These will not change if the company makes the entire investment. However, in some cases, the government is asked to share the cost.
- Contractor Production: Expected to decrease.

Benefits

- Reduced production costs with lower or no up-front costs to the government. Contractor has commitment and ownership.
- Both government and contractor gain through preservation of the program.

Caveats

Savings will be less if the quantity has to be cut. For example, benefits from initiatives will be less as a result of the F-22 fighter program being cut from 438 aircraft to 339.

If the company is bearing the entire cost, the government may not have visibility into the implementation process.

Results

There have been numerous cases of successful cost sharing by companies in the development of new products and even in carrying out of existing contracts, where the company gives up a portion of the cost to which it would otherwise have been entitled.

What To Look For

- Documentation of the nature of the investment and of the likelihood of achieving the planned savings.
- Evidence that there will be enough time for the initiative to take effect and to yield the required savings.
- Evidence of commitment of funds and energy by top management.
- Past performance on other initiatives.

2. Mergers and Acquisitions

A strategic corporate action taken by one company to combine with or acquire another company. The action typically includes restructuring of the combined entity.

Interdependencies

The merging of companies potentially affects most of the cost-reduction initiatives. However, the initiatives most directly affected are overhead reduction and vertical partnering. Other initiatives may be enhanced to the extent that greater corporate resources are required, such as development of modeling and simulation tools.

History of Implementation

With the decline of the DoD budget since 1987, contractors have undertaken mergers and acquisitions as part of their restructuring. This reflects the changes in the commercial sector during the same period, with substantial downsizing and restructuring efforts by many of the largest companies. Downsizing in the defense industry has lagged behind the commercial sector. DoD has promoted rational downsizing and accepted part of the costs in order to avoid the future cost of excess and outdated capacity.

DoD typically has reviewed the mergers and acquisitions to determine their consequences for the defense industry, but has expressed little concern about the activity. However, as the mergers have continued, DoD has begun to express concerns about possible anticompetitive aspects of some mergers and requested the Department of Justice to seek relief. The recent Raytheon-Hughes merger is an example where DoD expressed concern about competition and obtained relief through divestiture of certain business lines.

Hypothesized Effect on Cost

The organizations that are produced by mergers and acquisitions have the potential to reduce costs in all stages of procurement. However, the actual cost impact will depend on the circumstances of each reorganization.

Benefits

The potential benefits of mergers and acquisitions include:

- reduction in overhead as merged companies obtain economies from corporate support services, as plant utilization is increased due to combined programs, and as companies have greater purchasing requirements relative to their suppliers;
- downsizing and reductions in unneeded capacity, thereby saving DoD costs in future years; and
- increase in corporate resources the combined companies can put into product development and cost-reduction initiatives.

Caveats

The merging of companies may result in cost increases rather than cost reductions:

- If the company undertakes a significant restructuring after the merger, part of the restructuring costs may be allowable costs under the DFAR 231.205-70 External Restructuring Costs, eligible for DoD reimbursement. However, the reimbursement guidelines require that the ultimate savings to DoD of allowing the restructuring exceeds the costs to DoD of the reimbursement.
- The merger may involve vertical integration, causing a contractor to use its affiliated source rather than obtain outside competitive bids. Although profit cannot be passed from the affiliate to the contractor on a government bid, the cost of the affiliate may be substantially higher than what could be obtained through an outside competitive bid and a cost-efficient make/buy decision.
- The merger may involve the loss of sources at the lower tier, locking the government into sole-source relationships of which it is not even aware.
- The merger may reduce competition at the prime contractor or subcontractor level, allowing bidders to propose both higher costs and higher profit on future solicitations.

Results

DoD has reviewed certain mergers and acquisitions at the request of the Department of Justice and made recommendations regarding divestitures and maintenance of competition. For example, in the proposed Raytheon-Hughes merger, DoD argued that the merger would adversely affect competition for ground electro-optics systems and recommended divestiture of certain business lines.

DoD has funded allowable restructuring costs in a number of cases, but is now required to obtain a certain savings-to-cost ratio.

What To Look For

- Reduction in excess capacity, reduction in fixed overhead, and a subsequent reduction in overhead rates.
- Reallocation of General and Administrative Expense, such as home office expense of the acquiring company onto the acquired company.
- Whether the pricing approach of the acquired company must change in response to the FAR pricing requirements for affiliated companies.

3. Personnel Policies

The policies and practices of a company that deal with its employees (e.g., salary and benefits, incentives such as profit sharing).

Interdependencies

Personnel policies can facilitate overhead reductions. Movement of managers from the commercial side to the government side, or from pure commercial to mixed government/commercial, can facilitate many beneficial initiatives. Appropriate incentives to personnel can enhance all cost-reduction initiatives.

History of Implementation

No information.

Hypothesized Effect on Cost

Personnel policies can affect every phase of the acquisition process, but their effect will be most pronounced in the labor-intensive production phase.

Benefits

People are the key to the success of any cost-reduction initiative.

Personnel policies can directly affect the overhead rates charged by a company.

Caveats

The company with the lowest salary and benefit structures may not turn out to be the least expensive for the government. This is due in part to the company having a higher turnover rate than a company with more attractive salary and benefit packages.

Some companies have hoarded skilled labor (i.e., engineers) in lean times so as to have them available when they are needed. Although this practice raises labor costs in lean times, it is a rational approach due to the adjustment costs involved in changing the work force.

Results

Companies employ a wide variety of surveys and practices to determine and to bid labor rates and associated overhead rates. They sometimes use excessive planned turnover to bid lower rates, or propose bid rates that are not high enough to attract and retain the required personnel. They also sometime propose labor categories that are less expensive, but are not of a high enough level to support the statement of work.

What To Look For

- Specific policies and their expected effects in detail.
- Results of similar policies in this or other companies.
- Conformance of policies with common practices in the region or industry.
- Excessive labor turnover (past or projected).
- Adequacy of the labor categories to support the technical and performance requirements of the contracts.

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- Excessive labor turnover (past or projected).
- Adequacy of the labor categories to support the technical and performance requirements of the contracts.

4. Plant Location and Overhead Allocation

A strategic choice of development and/or production site to take advantage of regional differences in labor costs, labor/management structures and laws, expertise available, or other resources.

Interdependencies

- Possible response to dual-source competition.
- If plant is new, changing sites may disrupt benefits from long-term initiatives like continuous process improvement.

History of Implementation

No information.

Hypothesized Effect on Cost

After an initial investment to move a plant, lower labor and overhead costs have the potential to reduce costs, particularly in the production phase. However, disruptions and personnel issues could create unanticipated cost increases.

Benefits

Lower labor rates and accompanying overhead.

Caveats

There are costs associated with the relocation of capital equipment.

Skill levels may not be adequate to the task. Workers may lack necessary experience. If workers refuse to move, there may be problems due to lack of continuity of the labor force.

Difficulties of technology transfer (if an existing product) may stretch the schedule and increase costs.

Results

In 1995, the production of the E-2C aircraft was moved from Calverton, New York, to St. Augustine, Florida, in part to take advantage of lower labor costs and overhead rates.

What To Look For

- Documentation of appropriateness of site to the task required.
- Differences in labor rates from old site for comparable labor categories.
- Costs of moving equipment, new building, etc.

- Hiring costs for new workers.
- Documentation of availability of labor with appropriate skills and experience.
- Costs of transferring managers and key workers.
- Changes in overhead rates.

IV. ANALYTICAL APPROACH

A. INTRODUCTION

This chapter presents an analytical approach to evaluating cost-reduction initiatives. The approach is intended to assist cost, budget, program, contracting, and policy analysts to:

- predict the *cost or schedule savings* likely to result in a particular program from implementation of initiatives,
- evaluate *claims of cost savings* that initiatives will bring about in a particular program,
- ensure the *overall validity of cost estimation* when initiatives are included in the program,
- determine whether claims of cost savings based upon initiatives may be *double counting* the usual decline in unit costs due to program learning,
- assess the *cost or schedule realism* of a bidder's proposal that includes initiatives as part of its cost justification,
- estimate the *net savings* of initiatives from a government-investment point of view,
- determine whether initiatives change the fundamental *cost-estimating relationships* in a particular program, and
- assess the effects of *interdependencies* when multiple initiatives are used.

Analysts obtain information from a variety of sources, including: judgments of the program office or prime contractor, comparison to other programs (which may differ substantially from the program under consideration), anecdotal evidence, historical data, contractual outcomes, cost-estimating relationships, commercial programs and pricing of commercial products, contractor cost proposals and cost justification, cost realism analyses by the cost evaluation group of the source-selection team, and acquisition research studies. We recognize that the information will vary within a wide range of credibility, completeness, certainty, and objectivity. We also understand that the analyst typically will have less information than desired.

B. ISSUES TO CONSIDER

Before we describe our approach for evaluating cost-reduction initiatives, we want to mention several broader issues that may affect the evaluation process. First, the projected success of an initiative in reducing program costs depends to a significant extent on the stability of the program environment. Even if an effectively implemented initiative achieves the desired program changes, the resulting cost savings could be lost due to stretch-out of the production buy, changes in required system performance, or other program changes leading to cost growth. Therefore, the overall program environment is a significant factor in projecting the size, timing, and likelihood of savings from the initiatives. Our approach uses standard cost-estimating tools, but a program's structure and environment should not be ignored in considering the effectiveness of the initiatives.

Second, the projected success of an initiative also depends upon the extent to which it differs from standard company management and engineering practices. A company with little experience in a particular initiative may require a substantial learning period to implement it. Other companies may already use the initiative and therefore quickly achieve savings. Therefore, company experience with the initiatives, in either government or commercial projects, also should be considered. Given the increasing emphasis on past performance in source selections, consideration of experience with the initiatives for which savings are projected is consistent with the contracting process.

Third, savings may be more likely to result from a particular set of initiatives if the initiatives are contractual requirements, rather than just proposed management or technical approaches. Fourth, the savings are also more likely to result where subcontractor participation is clearly included in the initiative.

C. GUIDELINES FOR EVALUATION

The analysis of the effect of cost-reduction initiatives is unique to the specific initiatives implemented and to the program in which they are implemented. Each analysis may be thought of as a case study with its own unique contracting structure, funding environment, acquisition plan, source-selection plan, contractors' corporate goals and initiatives, technologies and products being acquired, acquisition initiatives employed by the government, and other factors. The approach we propose provides a general, systematic way to assess such information.

We propose "net program cost savings" as the appropriate measure of effectiveness for the initiatives. Further, so that the analyst understands how the initiatives create net program cost savings, the approach analyzes potential savings by contract line item number (CLIN), work breakdown structure (WBS), and cost element (direct cost, indirect cost, and fee). This aspect of our approach, discussed in section E, forces the analyst to specify the theoretical ways in which the initiative creates savings. It also requires those who present claims of savings to demonstrate where in the contract, the WBS, and the cost structure the savings will be realized.

To determine the effect of the initiatives in a particular case, cost-estimating tools, such as learning curve analysis or cost-estimating relationships, may be appropriate. However, in many cases, little objective information may be available. The analyst may have little more than rough savings estimates from similar systems. In these cases, it is possible at least to determine whether the savings projections are consistent with reasonable cost parameters. For example, suppose that a particular initiative in an airframe production contract is expected to cause overall cost savings. If the percentage of savings were consistent with a learning factor no higher than 50%, compared to the typical airframe factor of 85%, it would be clear that the claims of savings were not supported. In other words, the projected final cost, after implementation of the initiative, would not be consistent with normal cost parameters, even allowing for changes in the parameters due to the initiative. Therefore, when little direct information is available, comparison to other programs and to standard cost parameters may provide some understanding of the reasonableness of the claims.

Section F addresses the framework for assessing the savings, once the savings have been estimated. That framework is the budgetary model in which the savings are related to the program budget. This provides a useful and important assessment. However, the total budget impact of the savings ignores issues associated with the timing of the savings, whether the savings occur in the out-years, whether they are subject to cancellation or stretch-out, and whether substantial immediate investment expenditures are required. In order to account for the timing pattern of the savings and expenditures associated with an initiative, section G presents a standard investment framework for assessing the savings and costs from the viewpoint of the government as an investor. This provides a valuation of the initiatives beyond the total budget impact, requiring calculation of present value, constant dollar savings, and costs.

Section H presents three example analyses, focusing on production and support, design and test, and government acquisition initiatives. Finally, section I summarizes the structure and rationale of the approach presented in sections E through G.

D. MEASURE OF EFFECTIVENESS: NET PROGRAM COST SAVINGS

This analysis defines "net program cost savings" as the measure of effectiveness for evaluating cost-reduction initiatives. We use the term "net" to emphasize the fact that bottom-line cost savings are of interest, net of the cost of implementing the initiatives, such as investments in specialized software and equipment and the requirement for additional labor. We use the term "program" to emphasize the fact that total cost savings to the entire program are of concern, not just the savings associated with a particular initiative or phase of the acquisition cycle. We use the term "cost" to emphasize the fact that cost is the focus of the analysis, although the initiatives may have other beneficial effects. Therefore, net program cost savings is the appropriate focus of this analysis.

Cost-reduction initiatives are likely to occur as a set of initiatives in a program, rather than part of a set of initiatives. Further, the initiatives are likely to have interdependencies and counterdependencies. Therefore, the analysis must focus on the *net savings* the *entire set* of initiatives generates, which implies that net program savings rather than individual initiative savings is the appropriate measure of effectiveness.

Defining net program cost savings as the measure of effectiveness does not imply that decisions on whether or not to pursue the initiatives should be made solely on the basis of the projected cost savings. Other benefits of the initiatives may be considered to be more important than cost. For example, the initiatives may bring about improved product quality, a shorter development and production cycle, lower schedule and technical risk, a streamlined Request for Proposals (RFP) and source-selection process, an increase in software tools that can be used in other programs, or simplification of standards and specifications. Further, a decision could be made to use the projected savings to buy more systems, fund a product improvement program, or undertake other work within the program. The initiatives in that case would not reduce the ultimate cost to the government, yet they would still provide substantial value. The use of net program cost savings as the measure of effectiveness of the initiatives does not require its use as a program decision variable.

E. ESTIMATING NET PROGRAM COST SAVINGS

The first step in understanding the potential savings likely to result from implementation of the initiatives is to identify, in as much detail as possible, the types of costs that are reduced. This provides structure to the analysis and forces clarification of the expected effects. The second step is to understand the interdependencies and ensure that savings and costs are not double counted. The third step is to use cost tools, data, and whatever information is available to estimate the savings and costs. Each of these steps is considered here.

1. Cost Breakdown Categories: CLINs, WBS, and Cost Elements

To evaluate the initiatives, three types of cost breakdowns are appropriate: contract line-item number (CLIN), work breakdown structure (WBS), and cost element.

The CLIN breakdown identifies the phase of the contract in which the savings and cost are likely to occur. If the analysis of savings is carried out at an aggregate level or if the only data available for comparison is at the aggregate level, the CLIN breakdown may be the lowest level the analyst can address. For example, previous studies or experience with other programs may suggest a certain level of savings in the production phase of acquisition, but with little insight into the lower levels of the WBS or the cost structure. Therefore, the CLIN-level analysis may be appropriate.

The WBS provides a second cost categorization useful in the analysis. Because the WBS requires more detail than the CLIN breakdown, it requires more understanding of how the initiatives are intended to reduce costs or schedule. Even if data are not available for direct analysis at the WBS level, it is still a helpful structure for identifying the theoretical links between savings and initiatives and the links between initiatives.

The cost element breakdown provides a third way to analyze the potential savings. For the purpose of this analysis, and following the standard costing and pricing guidelines in the Federal Acquisition Regulation (FAR), total cost to the government can be thought of as consisting of direct cost, indirect cost, and fee. Each cost-reduction initiative must work through one or more of those categories to achieve a savings to the government. Knowing how direct cost, indirect cost, and fee are to be reduced by an initiative clarifies the rationale and justification for the initiative on a theoretical level and helps determine what information is required to develop a reasonable projection of savings. The cost element breakdown provides discipline, organization, and specificity to the analysis. It requires more of a detailed understanding of the initiative and the contractor's response than the CLIN and WBS breakdowns.

It is useful to divide total direct cost into two components, direct quantity and direct unit cost. Quantity refers to the total usage of direct cost items, such as direct labor hours and direct materials. Unit cost refers to the unit cost of each direct cost item, such as hourly direct labor rate per labor category and unit materials cost. The reason for considering those two components separately is that some initiatives may emphasize obtaining lower unit costs, while others may emphasize reducing the quantity of direct labor or materials. Lower unit cost obviously would imply no change in the production cost structure, but changes in quantities such as direct labor may imply a change in the cost-estimating relationships. In evaluating the initiatives, analysts may find it helpful to understand the basis of the reduction.

A reduction in direct cost may occur through a reduction in the unit costs for labor, materials, vendor purchases, and other direct cost items. A price reduction may occur, for example, as a result of increased competition at the subcontractor or vendor level. Alternatively, the prime contractor may develop a long-term supplier relationship with a vendor, permitting a lower unit price based on a forward pricing agreement. Dual-source and multiyear procurement may lead to reduced unit prices through the effects of competition and through the ability of the prime contractor to negotiate longer-term, lower-risk supply agreements. Plant relocation to areas of cheaper labor and materials cost and use of commercial standards and specifications are other examples.

Alternatively, a reduction in direct cost may occur through a reduction in the quantity of direct items required, such as direct labor and direct materials. For example, the just-in-time inventory initiative would reduce the cost of initial stock purchase and the ongoing cost of carrying a certain amount of material in inventory. The development of a virtual prototype may avoid the far greater level of engineering effort and expense for development of a physical prototype. The substitution of commercial specifications for military specifications may lead to direct cost savings through less engineering effort.

Another way to view the reduction in direct cost is as a result of improved cost relationships and more efficient processes in design, manufacturing, and support. For example, concurrent engineering, IPPDs, and IPTs offer an integrated, life-cycle approach, flexible work force development improves labor application, and the use of CAD/CAM shortens the cycle time. The cost-reduction initiative may improve the factors that drive costs, leading to a lower requirement for labor hours or materials. Concurrent engineering, IPPD, IPTs, automated test stations, and other initiatives reflect the ways in which the design, manufacturing, and support of the product are carried out and, therefore, potentially change the cost drivers and cost outcomes.

Reductions in indirect cost may result from a number of initiatives. Increased competition may lead contractors to bid less than their true overhead rate and even to cap their cost rate on cost reimbursable contracts. Contractors also may streamline and simplify their overhead structure, leading to lower indirect cost rates. Companies may reallocate part of their government overhead to other indirect cost pools, reducing the burden on government bids. Further, companies may undertake internal initiatives, such as activity-based costing, which identify and eliminate non–value-added activities.

In considering the effects of an overhead-reduction initiative, the analyst may find it useful to understand whether the reduction is likely to be applied to labor overhead (such as the fringe benefits structure), operating overhead (such as a streamlined plant management), or local and home office general and administrative (G&A) expense (such as a streamlined corporate management or reallocation of home office expense to nongovernment contracts). Because the overhead pools typically include engineering, manufacturing, materials handling, management, and other expense, they can be reduced, at least theoretically, by most of the design, manufacturing, management, and acquisition initiatives.

In addition, because indirect cost rates typically are applied to direct cost inputs, such as labor dollars or labor hours, the indirect costs will decline when direct costs decline, even if the indirect cost rates remain fixed.

The initiatives may bring about a reduction in total fee through a reduction in the cost base to which the fee is applied and through a reduction in the profit rate itself. For example, increased competition and lower prices may be responsible for lower vendor prices, including vendor profits. Not only would the vendor fee be lower, but the prime contractor's fee associated with the vendor pricing also may be lower since the cost base to which fee is applied declined. As a second example, multiyear contracting may lead to a reduction in risk and may enhance the ability of the prime contractor to negotiate longer-term agreements with vendors, both of which may lead to reduction in the profit rate.

2. Interdependencies and Double Counting

Many of the cost-reduction initiatives are interrelated, in either a positive or a negative way. For example, the use of a virtual prototype may strongly facilitate concurrent engineering, IPPD, IPTs, design assurance, and design for manufacture and assembly. All of those initiatives require integrated planning, integrated teamwork, and constant redesign and design testing. Virtual prototyping facilitates the teaming by providing a computer-based design model and a virtual environment that all members can use at once. It facilitates the redesign and design testing by providing a fast, less expensive way to achieve and test the redesigns. Therefore, the use of a virtual prototype may achieve cost savings by enabling those other initiatives.

However, note that the effectiveness, validity, and benefits of virtual prototyping are likely to depend critically upon the system and technology under consideration and, therefore, to vary widely across applications. Virtual prototyping should not be considered universally applicable to all products. Further, the use of virtual prototyping may be oriented to achieving more complex, advanced systems or to improving system performance within a cost ceiling, rather than to reducing cost.

In a similar way, a particular cost-reduction initiative may be facilitated by another initiative. For example, the development of a strong CAD/CAM platform would be a precursor to developing a full virtual prototype and virtual environment.

Finally, implementation of some initiatives may be detrimental to implementation of other initiatives. For example, a reduction in overhead may reduce a contractor’s ability to fund the development of CAD/CAM hardware and software tools, which would have provided a programming platform for development of a virtual prototyping capability. In this case, an immediate cost reduction is obtained through overhead reduction, but the opportunity for other initiatives may be foregone.

Interdependencies between initiatives potentially create a problem of double counting. The savings of the initiatives do not necessarily add in a linear way, based on the savings generated by each, but combine into a set of initiatives for the program that must be assessed as a whole. The lower the level of cost breakdown that can be undertaken, the less likely that double counting will occur. For example, at the CLIN level of breakdown, the analyst obtains little detailed insight into the way in which the initiatives achieve savings. At the WBS level, at least the functional areas are specified and double counting would be more apparent. At the cost element level, it would be most apparent that double counting occurred since it would be seen that the same costs were subject to reductions by several initiatives.

3. Cost Analysis

We previously defined net program cost savings as the measure of effectiveness to be used in assessing acquisition reform initiatives. We also defined three cost breakdowns as a framework for analyzing the savings: CLIN structure, WBS and cost element. CLIN is the most aggregated level, and cost element is the least aggregated. We noted that interdependencies exist among initiatives and may lead to double counting of savings. These guidelines set out a framework for tying the potential savings of the initiatives into the structure of the contract, the work breakdown structure, and the cost structure.

The challenge to the analyst is to estimate the expected savings of an initiative, to critique a claim of a certain level of savings, to determine whether fundamental cost relationships will be changed by the initiatives, to decide whether a proposed cost is realistic, and to avoid double counting the savings. Setting out the framework in as much detail as possible, by CLIN, WBS, or cost element, is a significant starting point. Specifying the cost effects in detail makes clear what other data are needed, what other analytic tools may be useful, and which prior studies are helpful.

Although no single analytical tool or methodology covers all initiatives and all types of products, delineation of the initiative according to the cost framework may suggest the most appropriate tool or data to apply. For example, suppose the analyst were considering the initiatives of overhead reduction, just-in-time (JIT) inventory, computer-aided manufacturing (CAM), and a winner-take-all competition for the final production run, after a period of dual-sourcing. The JIT initiative would lead to lower direct materials cost if the materials were charged as direct. It would lead to a lower material overhead cost if the materials were charged as indirect. In either case, fee may also decline as the cost base declines. This decline would lead to a shift downward in the learning curve for the relevant production lots. Similarly, the overhead reduction, if applied to a broad cost base, would be the equivalent of a downward shift in the learning curve. Given the size of the reductions, both effects could be estimated and the learning curve recalculated to determine the total savings. However, to the extent some materials costs were charged as overhead, it would be necessary to avoid double counting in the reduction.

The CAM initiative may also provide a downward shift in the learning curve by avoiding labor cost, increasing accuracy, improving testing, and obtaining other cost savings. However, the CAM initiative may also flatten the learning curve significantly, to the extent that there is less labor involvement and less opportunity for learning. Finally, the dual-source competition may lead to an overall cost reduction and an increase in the rate of learning, resulting in a steeper learning curve. The effects of these changes would be combined with the other initiatives to arrive at a projection of savings. The CAM initiative and the dual-sourcing have opposite effects on the rate of learning, while the other initiatives cause a downward shift in the learning curve.

Again, the assessment would take account of the possible double counting of savings among the initiatives. For example, dual-sourcing would not necessarily have an effect that is independent from CAM, JIT, and overhead reduction if the contractor used those initiatives as its response to the competition.

The above approach begins with the initiatives at the CLIN level and attempts to estimate the effects of the initiatives by making assumptions about the size and type of changes in the learning curve. However, the process may occur in reverse. Someone may claim that the combination of initiatives on the same contract will lead to a 40% cost savings to the government, but they cannot provide estimates of individual effects. The analyst in this case may begin with the expected learning curve at some standard rate, then determine what combination of reductions (due to cost and fee reduction), improvements in the learning rate (due to dual-sourcing), and decreases in learning rate (due to CAM) would lead to a 40% overall reduction. Each factor would then be tested to determine whether the required savings could be supported with data or comparison to other programs or in some other way. The analysis would also provide a test of reasonableness by determining, for example, whether the learning curves required to support the 40% savings were plausible based on other experience.

The above example illustrates the use of the learning curve, at the overall CLIN level, as a framework for estimating the effects of the four initiatives. However, if the initiatives could be specified in enough detail and at a sufficiently low level, one might use other cost tools or even established cost-estimating relationships. The point is that the cost tools and the analysis must be appropriate to the data and to the cost level required.

F. EVALUATING NET PROGRAM COST SAVINGS: BUDGET MODEL

The most straightforward way to evaluate the initiatives, once the savings and costs have been estimated, is to balance the estimated budget outlays the initiatives require against the projected cost savings over the life of the contract. The result is the estimated net program cost savings. The advantage of this approach is that the projected savings are related directly to budget outlays and are therefore understandable in the context of the program budget. In addition, this approach takes account of the costs and savings over the full life-cycle of the product, not just during the phase when an initiative is begun or when the results occur. However, this approach has several limitations.

First, the analyst may be interested only in whether the potential savings likely to be brought about by the initiatives support a particular budget projection. Further, the costs of the initiatives may be embedded in the projected budget in such a way that they cannot be directly identified. The key question is not what level of net savings to the program might be generated by the initiatives, but whether the program budget projections are realistic and justified given that the cost initiatives are planned. In such cases, disaggregation and further analysis can shed light on the issues.

Second, the confidence the analyst places in the estimate of net savings is limited by the data and the sources of information used to develop the estimate. The range of uncertainty may be as large or larger than the net projected savings, limiting confidence in the results.

Third, the budget model considers the size of the costs and savings, but not their timing. Timing is important for several reasons. First, timing reflects risk. If all of the expenditures for an initiative come early in the design phase, but the savings come only in the production or support phase, then the savings could be lost if the program is canceled. Similarly, if the total quantity buy over which the benefits can be realized is reduced, planned savings may be lost. For example, if a virtual prototype flight simulator were developed in the design phase for pilot training in the operation and support phase, realization of the savings would depend on the program's continuation. This situation represents a higher risk than one in which the savings were realized in the same phase of the acquisition cycle as the costs. Thus, two initiatives with identical costs and savings would have different risk profiles, depending on the timing of the savings.

Timing also reflects the economic value of the use of funds. Savings due to an initiative that occur sooner rather than later in the program have a higher value. Not only do they have a lower risk from a program viewpoint, they also have less exposure to inflation and they provide funds (either actual savings or lower required funding) sooner, reducing the opportunity cost of the savings. Even with minimal risk of cancellation, the timing of the savings affects their economic value. The following subsection presents an investment model of evaluation that takes account of the timing as well as the size of the savings and costs of the initiatives.

The costs of an initiative often can be specified in more detail and with more confidence than savings, since the initiatives may be priced in the contractor's proposals. The initiative may even be a separate CLIN or an element of the WBS. If the solicitation provides for a cost-reimbursable contract, the bidders often include detailed cost analyses to demonstrate to the government evaluators that their costs are realistic and should not be adjusted upward for evaluation purposes.

The projected savings of the cost initiatives, on the other hand, may be more difficult to estimate. Therefore, the assessment models may be used in the following way:

- First, what savings would be required to break even, given the projected cost of the initiatives?
- Second, what changes in key cost factors would have to occur to obtain that level of savings?
- Third, are the resulting cost factors reasonable in light of other experience?

This approach is similar to the one outlined above, which begins with the claimed savings, determines what combination of cost parameters' values would be consistent with the claimed savings, and, finally, assesses the reasonableness of those values in light of other experience. However, in this case, the analysis begins with the cost of the initiative, then determines what cost factors would have to result in order to achieve that level of savings.

G. EVALUATING NET PROGRAM COST SAVINGS: INVESTMENT MODEL

The investment model starts with the profile of projected outlays and savings (in constant-year dollars), discounts the costs and savings back to a present value (using the prescribed government discount rate), and calculates the present value of the net savings. The calculation of net present value provides the basis for an economic assessment of the projected costs and savings in a standard investment framework. This assessment supplements the budget model by considering not only the budget impact of the initiatives, but also the break-even period for investments in cost-reduction initiatives.

As is the case with the cost analysis and the budget model calculations, the investment model approach may be carried out in a straightforward way by entering assumptions about cost, savings, and timing into a present-value model to determine net present value. The approach also may be carried out in a reverse calculation:

- specify the cost and timing of the initiatives,
- calculate the present value of the cost,
- determine what combinations of size and timing of savings would lead to a break-even in the present value framework, and
- assess the realism of those combinations based on other experience.

H. EXAMPLES

1. Analysis of Production and Support Initiatives

The example described previously assumed the following four initiatives were to be undertaken in a production program: just-in-time (JIT) inventory, overhead reduction, computer-aided manufacturing (CAM), and winner-take-all competition after a period of dual-sourcing. It was claimed that with these initiatives in place, a net cost savings of 40% would be achieved.

We assume that the contract is for a fixed delivery of 100 units for the base year and 100 units per year in each of two option years. We also assume that the normal learning factor for this type of product is 90%.

A cost analysis indicates that the cost to the government for the contractor to set up the JIT is likely to be about $1.0 million. The overhead reduction is to be achieved by the contractors at no cost to the government. (However, it may also be achieved by simply moving these overhead costs to other government programs, such as other government programs in the same plant. In that case, there would be no change in the overall cost to the government.) We estimate that the CAM initiative will be undertaken at a cost to the government of $1.0 million the first year and $0.5 million in the two option years. Finally, the cost of the winner-take-all competition adds no incremental administrative cost to the government since the dual-source contract is ending and some procurement action will have to be taken, whether dual-source, competitive buyout, or negotiated sole-source.

Given the cost projections associated with the initiatives, three questions arise:

- Will the savings of the initiatives pay for the costs, yielding a positive budget impact?
- Do the expenditures for the initiatives lead to at least a break-even on an investment basis?
- Is 40% savings a reasonable claim, given the particular initiatives?

On the savings side, we expect the JIT and the overhead reduction together to lead to a 5% reduction in costs (and fee). We also estimate that the CAM will lead to an additional 5% reduction, but will also flatten the learning curve substantially because of the automation of key manufacturing procedures. Finally, based on other programs, we assume the effect of the competition will be to lower costs about 10% and increase the rate of learning somewhat. However, we also believe the 10% reduction from competition is accounted for to some extent by the use of CAM, JIT, and overhead reduction. To avoid double counting, we assume a net 5% cost reduction from competition. Thus, we assume a total reduction of 15%, which is the net of the direct effects and the interdependent effects of the four initiatives. We apply this reduction percentage to the first unit cost of the learning curve.

The first unit of production under this contract is the 300th unit produced in the program. The expected cost of $500,000 for the 300th unit implies a first-unit cost of about $1.19 million, based on the 90% learning curve. Therefore, the total expected contract cost is about $141.5 million. The expected overall reduction of 15% would lower the total cost to about $120.3 million.

The increase in the rate of learning from the buy-out competition is entirely offset by the automation of certain manufacturing activities, and the rate of learning actually decreases from 10% to 9%. This *decrease in learning* would cause the total cost to increase to $132.5 million. Since the incremental costs associated with the initiatives total $3.0 million, the total predicted costs with the initiatives would be $135.5 million. This represents net savings of $6.0 million from the expected baseline cost.

These calculations answer the first two questions above. The initiatives provide a net reduction in the budget and achieve more than a break-even on an investment basis. The answer to the third question requires more analysis. What combination of cost reductions and increases in the learning rate would be required to achieve a 40% reduction in total contract costs? The total costs would have to drop to $81.9 million. With the $3 million in implementation costs, the total cost would then be $84.9 million, reflecting a

40% reduction. The analysis indicates that, to obtain this savings, the contractor would have to achieve a 13% rate of learning and a nearly 23% reduction in first unit costs (or an equivalent combination). If these cost factors appear to be unreasonably optimistic and lie well outside of historical experience and reasonable judgment, then the 40% would not be justified without further evidence.

2. Analysis of Design and Test Initiatives

Suppose virtual prototyping, including creation of a virtual environment in which to test and operate the prototype, is to be introduced into a program as a possible cost-reduction initiative. The potential cost reduction occurs as a result of avoiding the cost of a more expensive physical prototype, along with the on-going design changes that would require further expense. In addition, the software may be reusable and part of the cost could be amortized over other programs. Further, the use of the prototype is expected to lead to shortening of the development cycle because redesigns can be tested faster and more members of the team can experiment with the prototype at a time. Finally, given the development of a virtual environment along with the virtual prototype, the prototype can evolve into a simulation training tool, providing a cheaper substitute for real-time operational training hours.

To support this initiative, the requirements analysis indicates the need for creation of a dedicated simulation facility, housing a virtual prototype and virtual environment with which to test three-dimensional, functionally accurate designs of a product in an operational environment. A detailed cost analysis indicates $25 million in the first year in construction and development costs, $2 million per year for the next 2 years in operations and support costs, and, finally, $3 million per year for a period of 5 years in operational simulation and training costs.

The total cost of the initiative would thus be $44 million. On a present-value basis, using a 5% discount rate and assuming the above estimates were in constant dollars, the cost is $40.5 million. Therefore, to achieve a break-even return on a budget basis, the savings would have to equal at least $44 million. On an investment basis, the present value of savings would have to be at least $40.5 million.

Further analysis indicates that the avoided cost of building a physical prototype and adapting it to design changes is expected to be $10 million in the second year and $8 million in the third year. In addition, the value of reduced cycle time is estimated at $2 million in years 2 and 3. Finally, we determine $5 million of real-time training costs can be avoided by using a simulator in years 4 through 8. Therefore, the total avoided cost is estimated to be $47 million which indicates the initiative has a favorable budget result over the 8-year period of $3 million or about a 6% net savings.

The present value of the savings is $40.1 million, less than the $40.5 million present value of expected costs. Therefore, because the costs are front-loaded and the savings are in the out-years, the initiative slightly falls short of the break-even point on a present-value basis. As a cost-saving investment, the initiative about breaks even. As a reduction in budget projections, it provides about a 6% impact. However, it is likely that the initiative also enhances other initiatives such as concurrent engineering, IPPDs, and IPTs and may provide substantial additional benefits through those initiatives.

3. Analysis of Government Acquisition Initiatives

Suppose a program has reached sufficient maturity and stability that it is a candidate for multiyear funding for the last 3 years of the production contract. The expected first-unit price at this point is $1.0 million. (Since this is again assumed to be the 300^{th} unit in the program, a 90% learning curve implies a first-unit cost of about $2.4 million.) The program office requirement is for 100 units for each of the next 3 years. With program experience of a 90% learning curve, the expected baseline cost for the 3 years is $283.1 million.

We believe that changing to a multiyear contract is similar to a buy-out and firms will bid very competitively. Even more competition among subcontractors and vendors may be possible if the government offers longer-term guaranteed buys. The stable funding of the multiyear contract will encourage contractors to invest in cost-lowering manufacturing technology that may not have otherwise occurred. Because the program is mature, we do not expect a substantial change in the learning rate, but we predict that a 15% reduction in first-unit cost will occur, thereby reducing the program cost to $240.6 million.

On the cost side, up-front purchases in response to economic order quantities could total as much as $21 million. There is also increased risk of termination cost as well as risk of increased cost if unanticipated changes occur in the program. Since the costs of multiyear contracting are in the risk and in the shifting of costs to the beginning of the program, the total costs will probably decline as indicated above. However, the shifting of the costs changes the present value of the savings somewhat. If we assume that up-front spending of $21 million would have been distributed as $7 million per year over the 3 years, the present value of the costs under the multiyear plan would be slightly higher. The present value under the baseline would be $142.0 million. The more substantial costs of multiyear contracting would be in the risks of cancellation, changes in quantity, and unanticipated changes in configuration or product upgrade.

I. SUMMARY

The approach recommended here for evaluating the savings and costs of acquisition reform initiatives is based upon several guidelines:

- First, establish net program cost savings as the measure of effectiveness of the initiatives, but recognize that other benefits may outweigh the cost considerations.
- Second, specify the cost and theoretical benefits of the initiatives in as much detail as possible. Use the CLIN, WBS, and cost elements as the framework. This specification helps determine what cost tools and other data may be useful in the analysis.
- Third, carry out the analysis in the context of a budget model to determine the projected budget impact of the costs and savings.
- Fourth, carry out the analysis in the context of an investment model to take account not only of the size but of the timing of the costs and savings.
- Fifth, depending on the purpose of the analysis, carry out the assessment in one of the following ways:
  - To estimate the costs and savings, enter the available information into the cost structure and calculate the net program cost savings.
  - To perform a break-even analysis in the budget model, specify the size of the costs, then determine what cost factors would have to result from the initiatives for the savings to equal the cost. In the investment model, specify the present value of the cost, then determine what combination of size and timing of savings would equal that present value. Finally, determine what cost factors would have to result from the initiatives to achieve those savings.
  - To assess claims that certain initiatives will lead to a certain level of savings, specify the theoretical cost effects of the initiative in as much detail as possible, determine what cost factors would have to result from the initiatives in order to achieve the savings, judge the reasonableness of those factors based on other experience and analyses, and ask for further justification.

V. RESOURCES

This chapter provides resources for additional information on initiatives. They are grouped into two areas—general and specific. General resources include programs that have adopted several initiatives, government offices, and industry contacts. Specific resources are organized by initiative. URLs for web sites cited here were current as of January 1998.

A. GENERAL RESOURCES

1. Acquisition Reform Sites

The Deputy Under Secretary of Defense (Acquisition Reform) supports the Acquisition Reform home page at www.acq.osd.mil/ar. The three military services also have Acquisition Reform Home Pages:

- Army: http://acqnet.sarda.army.mil/acqref/,
- Navy: http://www.acq-ref.navy.mil/, and
- Air Force: http://www.safaq.hq.af.mil/acq_ref/.

Each service also has some Acquisition Reform Success Stories:

- Army: http://acqnet.sarda.army.mil/acqinfo/zpsucc.htm,
- Navy: http://www.acq-ref.navy.mil/lessons.html, and
- Air Force: http://www.safaq.hq.af.mil/acq_ref/stories/stories.html.

The Acquisition Reform Communications Center (ARCC) is a directorate under the Defense Acquisition University (DAU). ARCC's site, located at http://www.acq.osd.mil/dau/arcc/index.html, provides information on continuing education broadcasts and prepackaged training materials.

The National Performance Review (NPR), at http://www.npr.gov/, is a Clinton-Gore Administration Initiative to create a government that works better and costs less. This site contains background information about NPR, information about recent award winners, and descriptions of various initiatives. It also contains a link to the Acquisition Reform

Network web site at http://www.arnet.gov/.

2. Acquisition and Contracting Issues

The Under Secretary of Defense (Acquisition and Technology) operates AcqWeb at http://www.acq.osd.mil/HomePage.html. The site has links to specific offices, policy documents, and a personnel directory. The Deputy Under Secretary of Defense (Acquisition Program Integration), Defense Acquisition Board (DAB) Executive Secretary provides updates on the 5000 series of DoD Directives and a list of major defense acquisition programs (MDAP) at http://www.acq.osd.mil/api/asm/. The Defense Acquisition Deskbook, at www.deskbook.osd.mil, provides a reference to mandatory and discretionary acquisition practices. It includes a library of relevant statutes and federal policy such as the Federal Acquisition Regulation (FAR) and OMB Circular A-76.

Defense Systems Management College (DSMC), at www.dsmc.dsm.mil, provides links to useful directories of acquisition terms and acronyms as well as to DSMC educational products and services.

The Defense Advanced Research Projects Agency (DARPA), at http://www.darpa.mil/, and the Defense Information Systems Agency (DISA), at http://www.disa.mil/, provide information about their current projects.

Defense Acquisition University, at www.acq.osd.mil/dau, provides course and schedule information, links to consortium schools, documents, and publications. Information about the Federal Acquisition Institute (FAI) is available at http://www.gsa.gov/staff/v/training.htm.

The Army Acquisition Corps provides professional development information for its members at www.dacm.sarda.army.mil. Information available includes career opportunities, career development guidelines, career management updates and contacts, professional publications, and education and training opportunities.

The Air Force Materiel Command (AFMC) Contracting Laboratory has a web site at http://farsite.hill.af.mil/ that contains information about Federal Acquisition Regulation (FAR). Additional information about the FAR is available at http://www.arnet.gov/far/.

Information about the Single Process Initiative (SPI) as well as other Acquisition Reform initiatives is available from the Defense Contract Management Command (DCMC) web site at http://www.dcmc.dcrb.dla.mil/Spi/Index.htm.

Several industry and professional organizations contain information concerning acquisition and contracting issues. These organizations include:

Commerce Business Daily (http://www.govcon.com/),

Electronic Industries Association (http://www.eia.org/), and

National Contract Management Association (http://www.ncmahq.org/).

3. Malcolm Baldridge National Quality Award

The Malcolm Baldridge National Quality Award was established to recognize US companies for performance excellence. The 1997 award criteria included quality in leadership, strategic planning, customer and market focus, information and analysis, human resource development and management, process management, and business results. Selected award winners include 3M Dental Products Division (1997), Ames Rubber Corporation (1993), AT&T Consumer Communications Services (now part of the Consumer Markets Division of AT&T) (1994), Cadillac Motor Car Company (1990), Corning Telecommunications Products Division (1995), Eastman Chemical Company (1993), Federal Express Corporation (1990), Globe Metallurgical Inc. (1988), GTE Directories Corporation (1994), IBM Rochester (1990), Marlow Industries (1991), Motorola, Incorporated (1988), Texas Instruments Incorporated—Defense Systems & Electronics Group (now Raytheon TI Systems) (1992), Trident Precision Manufacturing, Incorporated (1996), Wainwright Industries, Incorporated (1994), Wallace Co., Incorporated (1990), Westinghouse Electric Corporation—Commercial Nuclear Fuel Division (1988), Xerox Business Services (1997), and Xerox Corporation—Business Products & Systems (1989). For further information, visit the award site at http://www.quality.nist.gov/ or call the National Quality Program at the National Institute of Standards and Technology at 301-975-2036.

4. The Office of Naval Research's Best Manufacturing Practices Program

Benchmarking through comparing products, services, and practices is the purpose of the Office of Naval Research's Best Manufacturing Practices (BMP) program, established in 1985.

The Navy has an extensive data and information base on best manufacturing practices. Hard-copy reports are available from the BMP office and summaries are collected at www.bmpcoe.org/surveys/index.html.

The goal of the BMP program is to identify best practices being used in the areas of design, test, production, facilities, logistics, management, and environment, and to encourage industry and government to share information about these practices.

Independent government-industry survey teams visit organizations to gather information about their best processes. The information in the survey reports is designed to help organizations evaluate their own processes by identifying, analyzing, and emulating the processes of organizations that excel in specific areas.

Since the BMP program's inception, more than 95 organizations, including McDonnell Douglas; Lockheed Martin; Hughes Aircraft; Department of Energy National Laboratories (Oak Ridge Operations and Lawrence Livermore); NASA Marshall Space Flight Center and Kennedy Space Center; the City of Chattanooga; Nascote Industries; Weirton Steel Corporation; Mason & Hanger Corporation-Pantex Plant; Polaroid Corporation; the Society of Automotive Engineers; and Texas Instruments have participated in surveys.

The Best Manufacturing Practices Center of Excellence (BMPCOE), a joint effort of the Office of Naval Research; the National Institute of Standards and Technology, Manufacturing Extension Partnerships; and the University of Maryland at College Park, Engineering Research Center, was created to identify and promote exemplary manufacturing practices and to disseminate relevant information. BMPCOE's address is 4321 Hartwick Road, Suite 400, College Park, MD 20740. Point of contact is Mr. Ernie Renner, (301) 403-8100.

Table V-1 lists other Navy Manufacturing Technology Centers of Excellence.

5. Lean Aerospace Initiative at MIT

This program encompasses a broad menu of leanness initiatives. Based at the Massachusetts Institute of Technology (MIT), the Lean Aerospace Initiative (LAI) is a partnership among industry, government, labor, and MIT to achieve fundamental change in both the US defense aircraft industry and government operations. By building on and extending the "lean" paradigm, the program seeks to develop knowledge that will lead to greater affordability of systems, increased efficiency, and higher quality. The LAI consortium consists of government (tri-Service), industry, labor, and university sponsors and participants. The program is under the auspices of the Center for Technology, Policy and Industrial Development (CTPID), in collaboration with the Department of Aeronautics and Astronautics at MIT. For a description of the program, visit http://web.mit.edu/lean or see Stanley W. Kandero, "Lean Initiative Spurs Industry Transformation," Aviation Week & Space Technology, July 28, 1997, pp. 56–58.

Table V-1. Other Navy Manufacturing Technology Centers of Excellence

Center	Contact Name/Address	Phone/URL/E-mail Address
Center of Excellence for Composites Manufacturing Technology	Dr. Roger Fountain 103 Trade Zone Drive, Suite 26C West Columbia, SC 29170	(803) 822-3705 frglcc@aol.com
Electronics Manufacturing Productivity Facility	Mr. Alan Criswell Plymouth Executive Campus Bldg. 630, Suite 100 630 West Germantown Pike Plymouth Meeting, PA 19462	(610) 832-8800 http://www.engriupui.edu/empf
National Center for Excellence in Metalworking Technology	Mr. Richard Henry 1450 Scalp Avenue Johnstown, PA 15904-3374	(814) 269-2532 henry@ctc.com
Navy Joining Center	Mr. David P. Edmonds 1100 Kinnear Road Columbus, OH 43212-1161	(614) 487-5825 dave_edmonds@ewi.org
Energetics Manufacturing Technology Center	Mr. John Brough Indian Head Division Naval Surface Warfare Center Indian Head, MD 20640-5035	(301) 743-4417 mt@command.nosih.sea06.navy.mil
Manufacturing Science and Advanced Materials Processing Institute, ARL Penn State	Mr. Henry Watson P.O. Box 30 State College, PA 16804-0030	(814) 865-6345 hew2@psu.edu
NCADT/Drivetrain Center, ARL Penn State	Dr. Suren Rao P.O. Box 30 State College, PA 16804-0030	(814) 865-3537
SEMTC/Surface Engineering Center	Dr. Maurice F. Amateau P.O. Box 30 State College, PA 16805-0030	(814) 863-4214
Laser Center, ARL Penn State	Mr. Paul Denney P.O. Box 30 State College, PA 16804-0030	(814) 865-2934
Gulf Coast Region Maritime Technology Center, University of New Orleans	Dr. John Crisp Room N-212 New Orleans, LA 70148	(504) 286-3871

6. Affordable Multi-Missile Manufacturing

The Affordable Multi-Missile Manufacturing program (AM3) is an Advanced Technology Demonstration (ATD) sponsored by the Defense Advanced Research Projects Agency in cooperation with the Army, Navy and Air Force. AM3 will demonstrate advanced missile design and manufacturing concepts and manufacturing enterprise systems to reduce the cost of DoD's portfolio of tactical missiles and smart munitions. Funding for the missile sector has declined from a peak of about $9 billion per year in the mid-1980s to about $3 billion per year in FY 1995, a factor of three reduction. Quantities of missiles have declined by considerably more than a factor of three. The AM3 web site is at http://webhost.sainc.com/arpa/am3/.

7. Flagship Programs

The Flagship Programs are designated early implementers of CAIV.

- Joint Air-to-Surface Standoff Missile (JASSM) (http://www.jdamus1.eglin.af.mil/pub/jassm/jassm.html),
- Evolved Expendable Launch Vehicle (EELV) (http://www.laafb.af.mil/SMC/MV/eelvhome.htm),
- Space-Based Infrared Systems (SBIRS) (http://www.laafb.af.mil/SMC/MT/Sbirs.htm),
- Joint Strike Fighter (JSF) (http://www.jast.mil/html/jsf_homepage.htm),
- Air Intercept Missile (AIM–9X),
- Crusader—Advanced Field Artillery System/Future Armored Resupply Vehicle (AFAS/FARV),
- Multi-Functional Information Distribution System (MIDS) (http://www.acq-ref.navy.mil/mids.html), and
- Army Tactical Missile System-Brilliant Anti-Tank (ATACMS/BAT) Submunition Preplanned Product Improvement (P3I).

8. Pilot Programs

The pilot programs were an outgrowth of the Federal Acquisition Streamlining Act. Based on nominations from the military Services, DoD designated the following programs as statutory Defense Acquisition Pilot Programs (DAPPs) in December 1994:

- Joint Direct Attack Munition (JDAM) (http://www.jdamus1.eglin.af.mil/pub/jdam/jdam.html),
- Fire Support Combined Arms Tactical Trainer (FSCATT) (Army information at http://www-ngb5.ngb.army.mil/t3bl/fscatt.htm and Hughes web site at http://www.bgm.link.com/fscatt.html)
- Joint Primary Aircraft Training System (JPATS) (http://www.acq.osd.mil/ar/jpats.htm and http://www.safaq.hq.af.mil/acq_ref/stories/jpats_1.html),
- Commercial Derivative Engine (CDE) (http://www.acq.osd.mil/ar/cde.htm),
- Commercial Derivative Aircraft (CDA)/ Non-Developmental Airlift Aircraft (NDAA).

The Defense Personnel Support Center's subsistence, clothing, and medical programs and the C-130J Hercules tactical transport aircraft program were also designated as regulatory pilot programs (see http://www.dpsc.dla.mil/ and http://www.acq.osd.mil/ar/dpsc.htm). All of these programs have submitted metrics periodically to track their progress in acquisition reform.

The latest report, 1997 Pilot Program Consulting Group report, Under Secretary of Defense (Acquisition and Technology), Acquisition Reform can be found at http://www.acq.osd.mil/ar/pilot.htm.

9. Research and Analysis

The General Accounting Office (GAO) frequently assesses the potential savings from various initiatives. It is typically asked to assess the potential for savings from multiyear procurement contracts before Congress approves such arrangements. GAO publishes a monthly summary of reports issued. Current reports are available from the web site at http://www.gao.gov/, by writing P.O. Box 6015, Gaithersburg, MD 20884-6015, or calling 202-512-6000.

The Defense Technical Information Center (DTIC) (http://www.dtic.dla.mil/) serves as a repository for technical reports from IDA and other organizations. The address is 8725 John J. Kingman Road, Suite 0944 Fort Belvoir, VA 22060-6218, phone 1-800-CAL-DTIC (225-3842).

The 1997 report of an annual cost research symposium is available as "The 1997 IDA Cost Research Symposium," Stephen J. Balut, Document D–2025, Institute for Defense Analyses, July 1997.

Several of the federally funded research and development centers (FFRDCs) perform studies and analyses related to specific acquisition programs and their cost-reduction initiatives. These FFRDCs include

- Institute for Defense Analyses (http://www.ida.org/),
- RAND (http://www.rand.org/),
- MITRE (http://www.mitre.org/), and
- Software Engineering Institute (http://www.sei.cmu.edu/).

B. RESOURCES FOR SPECIFIC INITIATIVES

1. Design and Test Initiatives

a. Computer-Aided Design (CAD)

The Internet contains many sites with information about computer-aided design. An index of CAD information available on the web is contained on the design automation web page at http://jamaica.ee.pitt.edu/CAD_Sites/index.htm.

CADCAM Magazine provides information about new advances in CAD/CAM technology and can be viewed online at http://www.emap.com/cadcam/htm.

b. Concurrent Engineering

A lot of information about concurrent engineering can be found in Robert I. Winner, et al., *The Role of Concurrent Engineering in Weapons System Acquisition*, IDA Report R–338, Institute for Defense Analyses, December 1988. This paper defines concurrent engineering and lists some of the necessary elements of any concurrent engineering program. Also, the paper contains several case studies of companies that implemented concurrent engineering.

The NASA web pages on design for competitive advantage contain a page on concurrent engineering at http://akao.larc.nasa.gov/dfc/ce.html. This page contains some common definitions of concurrent engineering and also a bibliography of concurrent engineering papers.

The Society of Concurrent Engineering has a web page located at http://www.soce.org/.

c. Design Assurance

Dr. Edwards Deming's home page provides information about his work (http://www-caes.mit.edu/products/deming/home.html). Dr. Deming was one of the pioneers in the field of quality assurance and quality management.

A guide to the principles of quality management and quality assurance can be found at http://www.wineasy.se/qmp/qaqm.html.

d. Design for Manufacture and Assembly

Gerard Hock's "After 5 Years, What has GE Learned from Design for Assembly?"

is a case study on the impact of design for manufacture and assembly. It was presented to the International Conference on Product Design and Assembly in1986.

e. Integrated Product and Process Development (IPPD)

Version 1.0 of the DoD guide to Integrated Product and Process Development (IPPD) is located at http://www.acq.osd.mil/te/survey/table_of_contents.html.

A memorandum dated 10 May 1995 from Secretary of Defense William Perry entitled "IPPD Definition and Key Tenets" provides a brief outline of the key components of IPPD.

f. Modeling and Simulation Versus Testing

The Defense Modeling and Simulation Office (DMSO) has a web site, at http://www.dmso.mil/, with information about modeling and simulation in the military and in industry.

The Defense Systems Management College's web site contains links to various modeling and simulation sites at (http://www.dsmc.dsm.mil/relsites/rlstsgen.htm - Modeling and Simulation).

Some of the DoD policy memoranda and directives concerning Modeling and Simulation are:

- June 21, 1991, memorandum from the Deputy Secretary of Defense entitled "Modeling and Simulation Management Plan."
- July 22, 1991, memorandum from the Under Secretary of Defense for Acquisition entitled "Establishment of the Defense Modeling and Simulation Office."
- January 4, 1994, DoD Directive 5000.59 establishing DoD policy for the management of modeling and simulation.

g. Virtual Prototyping

The Defense Modeling and Simulation Office (DMSO) has a web site, at http://www.dmso.mil/, with information about modeling and simulation as well as virtual prototyping in the military and in industry.

2. Production and Support Initiatives

a. Automated Test Equipment

At http://www.rl.af.mil/Technology/SuccessStories/TWT.html you will find information from Rome Laboratory on the Air Force Traveling Wave Tube Automated Test Station Initiative.

b. Computer-Aided Manufacturing (CAM)

CADCAM Magazine (viewed online at http://www.cadcam-magazine.co.uk/) provides information about new advances in CAD/CAM technology.

A list of some vendors of CAM systems can be found at http://www.cam.org/~flamy/cadcam.html.

c. Flexible Automated Manufacturing Process

Some information about a flexible manufacturing system at Texas Instruments, including some of the claimed benefits, can be found on the Navy's Best Manufacturing Practices web site at http://www.bmpcoe.org/surveys/TIDS2C/TIDS2C_bp.html - BESTPRAC54.

d. Flexible Work Force

The Navy's Best Manufacturing Practices web site (http://www.bmpcoe.org/surveys/LME&MC/LME&MC_bp.html - BESTPRAC19) has a section on a flexible work force initiative at Lockheed Martin.

e. Just-in-Time (JIT) Manufacturing

One source for information about just-in-time manufacturing is J. O'Grady, *Putting the Just-in-Time Philosophy into Practice*, Nichols Publishing Company: New York, 1988.

The Navy's Best Manufacturing web site (http://www.bmpcoe.org/surveys/TIDS2C/TIDS2C_i1nfo.html - INFORMATION13) has information on just-in-time manufacturing at Texas Instruments.

f. Overhead Reductions

Information about overhead reductions and indirect cost management is available from DSMC at http://www.dsmc.dsm.mil/pubs/icmguide/icmguide.htm.

g. Reduced Cycle Time

Information on the schedules of previous programs can be found in M. B. Rothman, *Aerospace Weapon Systems Acquisition Milestones: A Database*, RAND Corporation, October 1987. Analyses of the factors influencing schedule include:

- Jeffrey A. Drezner and Giles K. Smith, "An Analysis of Weapon System Acquisition Schedules," RAND Corporation, Report R–3937–ACQ, December 1990.
- Bruce R. Harmon, Lisa M. Ward, and Paul R. Palmer, "Assessing Acquisition Schedules for Tactical Aircraft," Institute for Defense Analyses, Paper P–2105, February 1989.
- Bruce R. Harmon and Lisa M. Ward, "Methods for Assessing Acquisition Schedules of Air-Launched Missiles," Institute for Defense Analyses, Paper P–2274, November 1989.
- Bruce R. Harmon and Neang I. Om, "Assessing Acquisition Schedules for Unmanned Spacecraft," Institute for Defense Analyses, Paper P–2766, April 1993.
- Karen W. Tyson, Bruce R. Harmon, and Daniel M. Utech, "Understanding Cost and Schedule Growth in Acquisition Programs," Institute for Defense Analyses, Paper P–2967, June 1994.
- Bruce R. Harmon and Neang I. Om, "Schedule Assessment Methods for Surface-Launched Interceptors," Institute for Defense Analyses, Paper P–3014, August 1995.

h. Supplier Certification

The Navy's Best Manufacturing web site has information about the supplier certification initiatives at several companies, including:

- Raytheon (http://www.bmpcoe.org/surveys/RAYMSC/RAYMSC_info.html - INFORMATION15),
- Texas Instruments (http://www.bmpcoe.org/surveys/TIDS2C/TIDS2C_bp.html - BESTPRAC19), and
- Lockheed Martin (http://www.bmpcoe.org/surveys/LMGESC/LMGESC_bp.html - BESTPRAC24).

i. Use of Commercial Components

A Defense Science Board task force co-chaired by Dr. George H. Heilmeier and Dr. Larry Druffel examined the conditions under which defense software could be acquired commercially in a report dated 30 June 1994. A GAO report compared the Army's acquisition of its New Training Helicopter to private sector purchases of similar helicopters in "Acquisition Reform: Comparison of Army's Commercial Helicopter Buy and Private Sector Buys," NSIAD-95-54, March 1995.

3. Program Management Initiatives

a. Activity-Based Costing

An informative article about activity-based costing, including claimed savings is Joseph A. Ness and Thomas Thurman, "Tapping the Full Potential of ABC," *Harvard Business Review*, July-August 1995.

b. Continuous Process Improvement (CPI)

The results of the continuous process improvement (CPI) and total quality management (TQM) programs at Xerox are discussed in Gary Jacobson and John Hillkirk, *Xerox: American Samurai*, MacMillan Publishing Company, 1986.

Another source of information on CPI and TQM is J. Richard Nelson, James K. Bui, John J. Cloos, and David R. Graham, "Management Practices to Achieve More Affordable NASA Programs," Institute for Defense Analyses, Document D–1297, June 1993.

c. Electronic Commerce/Electronic Data Interchange (EC/EDI)

The Defense Information Systems Agency web page at http://edi.oti.disa.mil/certify/otheredi.htm contains links to a variety of web sites with information on EC/EDI.

A source of information on EC/EDI in DoD is the *Introduction to Department of Defense Electronic Commerce, A Handbook for Business,* located at http://www.acq.osd.mil/ec/newhandbook/cover/cover.htm. More general information is available from the electronic commerce office web site at http://www.acq.osd.mil/ec/.

d. Integrated Product Teams (IPTs)

Version 1.0 of the DoD guide to integrated product and process development (IPPD) is located at http://www.acq.osd.mil/te/survey/table_of_contents.html. This guide discusses IPTs and their role in IPPD.

A memorandum dated 10 May 1995 from Secretary of Defense William Perry entitled "IPPD Definition and Key Tenets" provides an outline of the key components of IPPD.

e. Make/Buy Outsourcing

The Outsourcing Institute, at http://www.outsourcing.com/, contains information about the potential benefits and common pitfalls of outsourcing.

f. Simplification of Management Hierarchy

An article concerning simplification of management hierarchy is Brian Andrews, "How Leaders Avoid the Scars of Organizational Liposuction (Downsizing)," *Houston Business Journal*, February 18, 1996.

The NASA web site at http://www.hq.nasa.gov/office/hqlibrary/ppm/ppm19.htm contains a list of references to books and articles concerning downsizing and simplifying the management hierarchy.

g. Total Quality Management (TQM)

A guide to the principles of quality management and quality assurance can be found at http://www.wineasy.se/qmp/qaqm.html.

Dr. Edwards Deming, a pioneer in the field, provides information about his work at http://www-caes.mit.edu/products/deming/home.html.

The results of the continuous process improvement (CPI) and total quality management (TQM) programs at Xerox are discussed in Gary Jacobson and John Hillkirk, *Xerox: American Samurai*, MacMillan Publishing Co. 1986.

Another source of information on CPI and TQM is J. Richard Nelson, James K. Bui, John J. Cloos, and David R. Graham, *Management Practices to Achieve More Affordable NASA Programs*, Institute for Defense Analyses, Document D–1297, June 1993.

Two DoD policy memoranda dealing with total quality management are:

- a March 30, 1998 memorandum from the Secretary of Defense entitled "Department of Defense Posture on Quality—the TQM Initiative," and
- an August 19, 1988 memorandum from the Under Secretary of Defense (Acquisition) entitled "Implementation of TQM in DoD Acquisition."

h. Vertical Partnering

The Navy's Best Manufacturing web site (http://www.bmpcoe.org/) has information about vertical partnering initiatives at several companies.

4. Government Acquisition Initiatives

a. Commercial Standards

"MilSpec Reform: Results of the First Two Years," Office of the Under Secretary of Defense for Acquisition and Technology/Acquisition Practices, June 1996 provides results of the initiative. It can be downloaded from the following web site: http://www.acq.osd.mil/es/std/whts_new.html. The Defense Standardization Program home page is at http://www.acq.osd.mil/es/std/stdhome.html. The core policy memorandum is William J. Perry, "Specifications & Standards - A New Way of Doing Business" June 29, 1994.

b. Cost as an Independent Variable (CAIV)

The major policy memo on CAIV is Paul Kaminski's "Reducing Life Cycle Costs for New and Fielded Systems," December 4, 1995. The December 1995 CAIV policy paper, CAIV Working Group, "Reducing Life Cycle Cost of New and Fielded Systems (Cost as an Independent Variable)," can be viewed at http://www.acq.osd.mil/api/asm/caiv.pdf. Lessons from the AIM-9X and MIDS programs can be found at http://www.acq-ref.navy.mil/lessons.html.

The Flagship Programs, described in the General Resources section of this chapter, are early implementers of CAIV.

b. Contract Incentives

There is extensive literature on the economics of incentive contracting. See, for example:

- Frederic M. Scherer, *The Weapons Acquisition Process: Economic Incentives*, Harvard University Press: Boston, 1964.
- David P. Baron, "Incentive Contracts and Competitive Bidding," *American Economic Review*, Vol. 62, (June 1972), pp. 384–94.
- J. Michael Cummins, "Incentive Contracting for National Defense: A Problem of Optimal Risk-Sharing," *Bell Journal of Economics*, Vol. 8, No. 1 (Spring 1977), pp.168–86.
- R. Preston McAfee and John McMillan, "Bidding for Contracts: A Principal-

Agent Analysis," *Rand Journal of Economics*, Vol. 17, No. 3, (Autumn 1986), pp. 326–38.

See US General Accounting Office, "Incentive Contracts: Examination of Fixed-Price Incentive Contracts," GAO/NSIAD-88-36BR, November 1987, for an empirical study of the outcomes of a set of incentive contracts of various sizes. A study of Army cost-plus-incentive-fee contracts (initial price $500,000 or more) is in Robert L. Launer, *Cost Growth: Effects of Share Ratio and Range of Initiative Effectiveness*, Army Procurement Research Office, Fort Lee, Virginia, July 1974.

The following papers contain chapters on incentive contracting, with information on the impact of such contracts on acquisition outcomes:

- Karen W. Tyson, J. Richard Nelson, Neang I. Om, and Paul R. Palmer, "Acquiring Major Systems: Cost and Schedule Trends and Acquisition Effectiveness," Institute for Defense Analyses, Paper P–2201, March 1989.
- Karen W. Tyson, Neang I. Om, D. Calvin Gogerty, J. Richard Nelson, and Daniel M. Utech, "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs," Institute for Defense Analyses, Paper P–2722, November 1992.

c. Dual-Source Competition

See the following:

- Charles H. Smith, "Evaluation of Competitive Alternatives for Weapon System Production," in Richard Engelbrecht-Wigans, Martin Shubik, and Robert M. Stark, eds., *Auctions, Bidding and Contracting: Uses and Theory*, New York University Press, 1983, pp. 421–435 [a theoretical treatment of the issue].
- L. A. Kratz, J. W. Drinnon, and J. R. Hiller, "Establishing Competitive Production Sources: A Handbook for Program Managers," ANADAC, Inc., August 1984.
- Karen W. Tyson, Neang Om, Calvin Gogerty, J. Richard Nelson, and Daniel M. Utech, "The Effects of Management Initiatives on the Costs and Schedules of Defense Acquisition Programs," Institute for Defense Analyses, Paper P–2722, November 1992.
- Brian Flynn and Dennis Herrin, "Results of Competitive Procurement in the 1980s," Naval Center for Cost Analysis, December 1989.

d. Multiyear Procurement (MYP)

Congressional guidance on multiyear procurement is often given in the annual defense appropriation legislation. The GAO (http://www.gao.gov) is typically asked to assess savings estimates before congressional approval is sought. See, for example:

- T-NSIAD-96-137: "C-17 Aircraft: Comments on Air Force Request for Approval of Multiyear Procurement Authority," Testimony, March 28, 1996
- NSIAD-96-199: "Army Acquisition: Javelin Is Not Ready for Multiyear Procurement," September 26, 1996
- NSIAD-98-11: "Apache Longbow Helicopter: Fire Control Radar Not Ready for Multiyear Procurement," Letter Report, November 17, 1997.

e. Performance-Based Specifications

The DoD Standardization Program home page is a valuable resource for tracking the continuing clarifications of this policy (http://www.acq.osd.mil/es/std/stdhome.html).

Key policy memoranda include:

- Secretary of Defense William Perry, "Specifications & Standards - A New Way of Doing Business," June 29, 1994, http://www.acq.osd.mil/es/std/perry.html.
- R. Noel Longuemare, "Requiring Processes on Contract," September 18, 1997, http://www.acq.osd.mil/es/std/processes.htm, clarifies the extent of the policy of not requiring standard management approaches or manufacturing processes in solicitations and contracts, but rather relying on performance-based requirements whenever practicable. "The policy applies to processes from any source whether MIL-STD, industry standard, company process, locally prepared technical document, or a process written into the system specification or other solicitation or contract document."

Some GAO reports on the subject include:

- "Acquisition Reform: Comparison of Army's Commercial Helicopter Buy and Private Sector Buys," Letter Report, GAO/NSIAD–95–54, March 17, 1995.
- "Acquisition Reform: DOD Begins Program to Reform Specifications and Standards," Letter Report, GAO/NSIAD–95–14, October 11, 1994.
- "Acquisition Reform: Efforts to Reduce the Cost to Manage and Oversee DoD Contracts," Letter Report, GAO/NSIAD–96–106, April 18, 1996.
- "Acquisition Reform: DOD Faces Challenges in Reducing Oversight Costs," Letter Report, GAO/NSIAD–97–48, January 29, 1997.

5. Corporate Policies

a. Corporate Program Investment

Corporate program investment is particularly difficult to assess, because of lack of visibility into the firm's internal financial data. The analyst can work to obtain a sense of the firm's position in the marketplace through the financial press and industry trade journals. The Securities and Exchange Commission's EDGAR database (http://www.sec.gov/edgarhp.htm) contains financial information reports (Form 10-K) for public companies. Other sources include: Moody's Investors Service (http://www.moodys.com/), Standard and Poor's (http://www.stockinfo.standardpoor.com/), Hoover's Online (http://www.hoovers.com/), and Dun and Bradstreet (http://www.dbisna.com/dbis/dnbhome.htm).

b. Mergers and Acquisitions

A section of the 1995 Annual Defense Report, "Economic Security—New Ways of Doing Business at Defense," proposes a more active role for DoD in analyzing and monitoring mergers in the defense industry. It can be viewed at http://www.dtic.dla.mil/execsec/adr95/econ_5.html.

Comments from an April 1997 Air Force Defense Industrial Base Conference can be found at http://www.abm.rda.hq.navy.mil/event2.html.

c. Personnel Policies

See the Baldridge Award Winners for information on successful personnel policies. The American Management Association and the Harvard Business Review are other potential sources.

d. Plant Location and Overhead Allocation

The Bureau of Labor Statistics (http://www.bls.gov/datahome.htm) collects data on regional wage and price differences, important factors in evaluating plant locations.

ABBREVIATIONS

ABC	Activity-Based Costing
ACAT	Acquisition Category
AFAS	Advanced Field Artillery System
AFMC	Air Force Materiel Command
AIM	Air Intercept Missile
AM3	Affordable Multi-Missile Manufacturing
ANSI	American National Standards Institute
ARCC	Acquisition Reform Communications Center
ASQC	American Society for Quality Control
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
BAT	Brilliant Anti-Tank
BAU	business as usual
BMP	Best Manufacturing Practices
BMPCOE	Best Manufacturing Practices Center of Excellence
CAD	computer-aided design
CAIV	cost as an independent variable
CAM	computer-aided manufacturing
CATIA	computer-aided, three-dimensional interactive application
CDA	Commercial Derivative Aircraft
CDE	Commercial Derivative Engine
CDRL	Contract Data Requirements List
CLIN	contract line item number
CPI	continuous process improvement
CTPID	Center for Technology, Policy and Industrial Development
DAB	Defense Acquisition Board
DAPP	Defense Acquisition Pilot Program
DARPA	Defense Advanced Research Projects Agency
DAU	Defense Acquisition University
DCMC	Defense Contract Management Command
DISA	Defense Information Systems Agency
DMSO	Defense Modeling and Simulation Office

DoD	Department of Defense
DSB	Defense Science Board
DSMC	Defense Systems Management College
DTIC	Defense Technical Information Center
EC	electronic commerce
EDI	Electronic Data Interchange
EELV	Evolved Expendable Launch Vehicle
EMD	Engineering and Manufacturing Development
FACNET	Federal Acquisition Computer Network
FAI	Federal Acquisition Institute
FAR	Federal Acquisition Regulation
FARV	Future Armored Resupply Vehicle
FASA	Federal Acquisition Streamlining Act
FFRDC	federally funded research and development center
FSCATT	Fire Support Combined Arms Tactical Trainer
G&A	general and administrative
GAO	General Accounting Office
GM	General Motors
IDA	Institute for Defense Analyses
IPPD	integrated product and process development
IPT	integrated product team
ISO	International Standards Organization
JASSM	Joint Air-to-Surface Standoff Missile
JAST	Joint Advanced Strike Technology
JDAM	Joint Direct Attack Munition
JIT	just in time
JPATS	Joint Primary Aircraft Training System
JSF	Joint Strike Fighter
KPP	key performance parameter
LAI	Lean Aerospace Initiative
M&S	modeling and simulation
MDAP	major defense acquisition program

MIDS	Multifunctional Information Distribution System
MIT	Massachusetts Institute of Technology
MYP	multiyear procurement
NC	numerically controlled
NDAA	Non-Developmental Airlift Aircraft
NPR	National Performance Review
O&S	Operations and Support
OEM	Original Equipment Manufacturers
PDRR	Program Definition and Risk Reduction
PDT	Product Development Team
RDT&E	research, development, test, and evaluation
RFP	Request for Proposals
SBIRS	Space Based Infrared Systems
SPC	statistical process control
SPI	Single Process Initiative
STOVL	short takeoff and vertical landing
TEAMS	Team Enhancement and Management Strategy
TI	Texas Instruments
TQM	total quality management
TWT	Traveling Wave Tube
WBS	work breakdown structure

We Need To Hear From You

This handbook is a work in progress. In order to keep the information current and useful to you, the user, we need to know not only your experiences with cost-reduction initiatives, but also your comments about the handbook itself. To let us know what you have to say, fill out and tear out this pre-addressed page. Either, fold, stamp, and mail it, or fax it to Karen Tyson at 703-845-6888.

Your Name:____

Title:____

Address:____

City:_______________**State:**_______________**Zip Code:**_______________

Phone Number:_______________________**E-mail Address:**_______________________

Comments:____

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