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The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicing acquisition professionals with relevant management tools and information based on recent advances in policy, management theory, and research. The ARQ addresses the needs of professionals across the full specturm of defense acquisition, and is intended to serve as a mechanism for fostering and disseminating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decisions, and for maintaining a high level of awareness regarding acquisition management philosophies.

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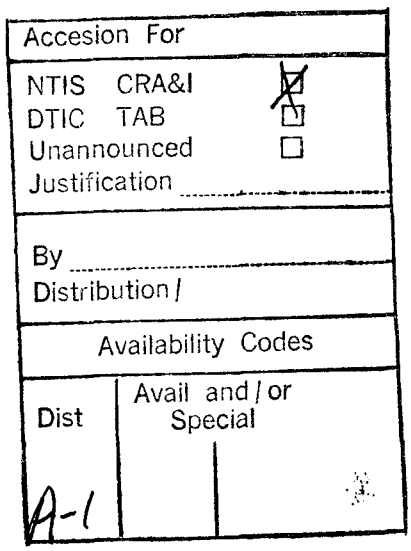
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ACQUISITION REFORM: IT'S NOT AS EASY AS IT SEEMS

Mark Cancian

The current acquisition system represents trade-offs among many competing and often contradictory goals. This article explores the various objectives the system is designed to achieve, the priorities of different players, the trade-offs among the priorities, and the prospects of future reform.

The acquisition system is broken and needs to be fixed. How many times have officials said this? From the Secretary of Defense, who pledged during his confirmation hearings to "institute innovative management techniques to vigorously foster acquisition reform" (U.S. Senate, 1994), to the head of the American Defense Preparedness Association, who called for "[acquisition reform that is] so desperately needed by the defense industrial base" (Skibbie, 1993), DoD officials, industry executives, outside experts, and academics voice the same complaint.

This opinion is also shared by the public at large. When asked how much waste, fraud, and abuse there is in the defense budget, 68 percent in one poll answered "a lot" and another 28 percent answered "some." In another poll Americans believed by an 87 percent to 10 percent margin that "there is too much waste in defense spending" (Americans Talk, etc., 1988; Harris, 1985).

Reinforcing this impression of waste and inefficiency are the continuous public efforts at reform. Over the years commission after commission has called for reform (Packard Commission, 1986; et al.). If the problem is so clear, then why is improvement so hard?

The usual answer is that "special interests" and "obstructionist bureaucrats" are preventing progress. After all, who else would defend an obviously broken system? Conscientious, public-spirited people want change, while selfish, short-sighted people want to maintain the current corrupt, inefficient system.

This depiction shows why so little progress has been made. In fact, *the current system is not broken. It is well designed to accomplish the goals that the nation values.* But how can this be when so many people are critical of the system? The reason is simple: different players have different goals and priorities. The current system rep-

resents trade-offs among many competing, often contradictory goals and, not surprisingly, works imperfectly as a result. "Acquisition reform" is not a matter of fixing a system that is broken. For each player it is a matter of wanting to redesign the system to favor what they value.

That these trade-offs exist is no secret. Both Perry and Colleen Preston, the Assistant Deputy Under Secretary of Defense for Acquisition Reform, have indicated this. For instance, Perry has stated: "My opinion is that the level of management control is probably appropriate for the acquisition system we have. Therefore, we're going to have to change the system in a fundamental way."

Unfortunately, the demands of public rhetoric today push the discussion towards fixing the system rather than making trade-offs. Trade-offs mean that one must give something up to gain something of greater value, but public discussions today do not allow for talk of sacrifice. Hence, there is an inclination to characterize the problem as if the nation could get something for nothing, thereby fixing the problem. These two approaches collide when an actual reform package has to be proposed. Because any reform must, in effect, be a trade-off, the losers cry foul and oppose the package. This is what happened with the most recent administration package.

This article explores why something that virtually everyone professes to want, acquisition reform, is so hard to actually attain. The article discusses the different objectives that the acquisition system is designed to achieve, the priorities of the different players, the trade-offs among the priorities, and finally looks at future reform prospects.

Why is Defense Different?

Before going further it is worthwhile reminding ourselves why this problem is so hard. Yes, we all know that the defense industry is different. However, reviewing the reasons why this is so will put the discussion about reform into perspective and remind us of how different the defense industry actually is from commercial industry (Fox, 1974):

1. There is one buyer—a monopsony—and hence no true market;

2. For any particular item, there is often only one or at most a very few sellers;

3. The user's "bottom line" is not financial but performance. Competition therefore strongly emphasizes performance over price;

4. Major contracts are signed years before actual results are available and therefore must be based on estimates of cost, schedule, and performance;

5. Performance is difficult to judge, and is often judged subjectively, except for the rare occasions when the nation actually uses military force on a large scale;

6. The enterprise operates with public funds, the use of which is held to a different standard than private funds;

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7. Decisionmaking power is diffuse, being shared between the executive branch and the legislative branch (with its many committees and subcommittees); and,

8. Decisions and operations are conducted in the open, under great public scrutiny.

J. Ronald Fox, in his classic study of defense acquisition, concluded from these characteristics, that "There is no sensible reason to deny the obvious... The basic tenets of the free enterprise system do not apply" (Fox, 1974, p. 474). As a result many, perhaps most, business practices common in commercial industry for evaluating and controlling operations have no application in the defense world. There are few objective criteria by which to judge defense activities and outcomes. Mostly these judgments are subjective, based on professional knowledge and experience that can be radically different for different people.

So what are the competing goals that the system is trying to accomplish? The number of items could be virtually infinite, but the list below is a good start:

1. *Performance (faster, higher, farther)*: There is always pressure to push the envelop of technology. Sometimes this is in response to a particular threat. At other times it is a more general desire to gain a battlefield advantage against potential opponents;

2. *Cost Minimizing*: Obviously, the less something costs, the more you can buy;

3. *Schedule*: Anything worth having is worth having immediately;

4. *Risk*: Minimizing the possibility that something goes wrong;

5. *Control*: Allowing senior officials adequate warning of possible problems and the means to intervene to correct them;

6. *Jointness and Interoperability*: Able to be used by more than one service and to interact with the equipment of other services;

7. *Industrial Base*: Ensuring that the defense industry stays in business and can produce needed equipment in the future;

8. *Fairness and Propriety*: Treating all participants properly. Because this is a public, very open process, all decisions and procedures must be justified, not only to the few involved, but to the public and its representatives. This goes beyond legality to include propriety. Seemingly arbitrary decisions that may be acceptable in a private context are not acceptable for a public enterprise; and,

Because this is a public, very open process, all decisions and procedures must be justified...

9. *Socioeconomic*: Advancing certain national goals such as encouraging small businesses, promoting minority- and women-owned businesses, strengthening unions, and buying U.S. products. These goals are often regarded as illegitimate by people inside the system because they have no direct bearing on national security or on acquisition. Indeed, they look like the workings of powerful special interests trying to bend society's rules in their favor. However, democracy is a messy form of government. One person's selfish special interest is another's vital national priority. Furthermore, every national process inevitably gets involved with these kinds of national policies. Consider, for instance, the tax system and its many special provisions that have no bearing on revenue generation.

Of course, all the players in the acquisition process care about all these goals. However, they do not care about the goals equally. At the risk of caricaturing some of the players, here is an analysis of what the major players value most:

The Defense Industry: Industry exists to make a profit. In public debate this is almost embarrassing to acknowledge but is nevertheless true. After profitability industry wants to stay in business (usually characterized as "maintaining the industrial base") and wants to have as little interference as possible. The defense industry looks with envy at its commercial sisters who don't have legions of auditors, inspectors, staffers and contract administrators looking over their shoulders. Industry's perspective on acquisition reform is clearly contained in a package put together by a coalition of associations. This package focuses entirely on government oversight and imposed requirements (Defense Acquisition, etc., 1993).

The Program Manager: He wants to field something. He is judged as having a successful program if, at the end, the troops get a new piece of hardware. Cost, schedule, and even performance mean nothing if the hardware is not fielded.

The Military Services and Ultimate Users: The services are tasked with equipping units for use by the combatant commanders-in-chief and hence are required to represent the user's interests. They care above all about getting equipment that will give them a warfighting advantage. Ultimately, this means high performance on a rapid schedule. Cost and everything else are secondary.

The Office of the Secretary of Defense (OSD): Historically, OSD has cared first about executing the acquisition contract. This minimizes risk and ensures control (or at least the illusion of it). All acquisition programs have signed a contract, either explicitly in the Defense Acquisition Board (DAB) Acquisition Decision Memorandum (ADM) or implicitly in various program and budget decisions. OSD expects to see these contracts carried out and works to minimize risk of deviation. Second, OSD cares about the affordability of the overall defense program. Ultimately all programs must fit within the allocated top line, and there are always more programs than there are resources. Program cost, therefore, gets close scrutiny. Finally, jointness, and the interoperability it implies, offers the prospect of better joint warfighting (of great interest to the Joint Staff particularly) and of common equipment (and therefore lower costs).

The Congress: The Congress is moved primarily by its fiduciary responsibilities; that is, the need to ensure that public moneys are seen to be used in ways consistent with national purposes. Here the end does not justify the means; the means must stand on their own. This concern is often characterized by a focus on fraud, waste, and abuse. This concern is shared by an American public who strongly distrusts both the military in its procurement activities and the defense industry. The result is that many members distrust the department. The Congress therefore believes that without explicit guidance and close scrutiny the department will waste money. The Congress also, as a national proponent of socioeconomic goals, desires to see these furthered by the acquisition system.

How Does This Affect Reform?

Because of these differing values acquisition reform is like the tale of the blind men and the elephant, where each participant characterizes the whole by the part he is closest to. For industry, acquisition reform

is reducing interference; for the Congress, it is improving safeguards; for yet others, it is reducing risk. As a result all agree that acquisition reform is vital, a must-do for any administration, but cannot agree on an actual set of actions.

As noted earlier, the essence of any acquisition reform is a trade-off among desirable goals. Three high visibility examples here make the point:

1. Black (special access) programs are those that require very high security. The acquisition system for black programs is attractive to some because many of the reviews, analyses, and outside interference of the traditional system are removed. Black programs trade off control and frequently cost for an accelerated schedule and a much higher acceptance of technical risk. They can have tremendous successes. The F-117, for instance, was a black program. It was developed quickly and overcame large technical problems (e.g., two of the first prototypes crashed) that might have terminated an open program. As a result of these advantages, the acquisition process for black programs is often held up as a model for the entire acquisition system. Indeed, there is suspicion that the department has been moving in this direction because during the 1980s the size of black programs grew tremendously, more than merely the progress of technology would seem to require.

   However, there is a downside to the black system also, as the A-12 experience showed. Here the lack of visibility into the program, the lack of reviews and analysis (among other managerial failings) and the compartmentation of information allowed serious problems to develop and grow. When they became known, it was more attractive to cancel the program than to try to save it. The result was a severe blow to naval aviation.

2. Dual use technologies and commercial off-the-shelf (COTS) technologies are currently extolled as ways to save money and accelerate the acquisition process. They offer the prospect of using a much larger industrial base and of harnessing the vitality and drive of the commercial sector.

   Indeed, for certain kinds of products where technology is moving rapidly (information processing, for example) commercial products give both lower price and higher performance. Commercial products, even with their limitations, come from processes that are much more agile than the defense acquisition system.

   However, in other areas commercial products often involve a trade-off. Cost may be lower, and schedule may be faster. However, performance, broadly defined, is also often lower.

   Commercial products are not built to the demanding environmental and stress standards attained by military articles. For example, few commercial products are required to operate at temperatures ranging from 40 degrees below zero to 140 degrees above. But military equipment often does need this capability, and users will be disappointed if the equipment does not have it. For instance, one recently developed military training system extensively incorporated COTS components but found that the CRTs cracked in field handling, that the system

...where technology is moving rapidly...commercial products give both lower price and higher performance.

couldn't take the extremes of heat and cold, and that the system's air conditioning unit disintegrated under vibration.

COTS equipment will frequently lack all the features that the military desires. A large scale example would be buying commercial aircraft like the 747 instead of the C-17. The 747 has impressive capabilities and is much cheaper. However, it lacks a wide range of capabilities that the C-17 has, for instance: the ability to handle oversized and outsized cargo, the ability to land on short and rough fields, self-protection capabilities, the ability to back up on an incline, and many others.

The department can get different, often less capable, equipment for less money.

Military Specification (milspec) items are, by definition, interoperable with other military items. COTS items may not be interoperable if there is no industry-wide standard.

Finally, commercial products rarely come with the documentation and support that milspec items do. For instance, a milspec software procurement will include enough documentation so that the code can be changed later. A commercially acquired software package would not. Similarly, a milspec procurement often includes a technical data package so that multiple producers could compete in building the item. A commercial procurement would not. These limitations of COTS would be as easy for outsiders to criticize as the milspecs they replace. Indeed, one can well imagine a future GAO report entitled, "DoD buying Insupportable and Incompatible Equipment."

None of this means that COTS acquisition is not worth doing. It does mean that there is a trade-off that is often unrecognized. Indeed, this is particularly true with COTS because the implication is often made that the department can get the same equipment for less money. This is rarely true. The department can get different, often less capable, equipment for less money. Frequently this trade-off will be attractive because the milspec capability is "nice to have," but not essential, especially in a time of severe budgetary constraints. Usually, however, there is a real loss.

3. The most important trade-off, however, is between the risk of abuse and the level of oversight. Reductions in oversight, the essence of many reform notions (especially from industry), mean that more things will go wrong and that they will remain unseen longer. If viewed from purely a cost-effectiveness standpoint, however, one could easily believe that less oversight would be more effective. After all, no commercial operation maintains this high level of oversight, so it is probably not cost-effective for the government despite its different circumstances (DoD's Cost, etc., 1992).

But as the earlier analysis of system goals and players' values indicated, cost effectiveness is only one criterion. Public visibility and fiduciary responsibility to the taxpayers also count heavily. The acceptance of risk trades these off to some extent. It says, in effect, that we accept the fact that more things will go wrong, but it is not worthwhile trying to prevent them. In our private lives we do this often. In our public lives as a nation it is much more difficult to acknowledge this. Furthermore, there is the risk of a "mega-problem" the size of the savings and loan disaster that develops unseen and

then explodes with huge consequences.

The perception of fairness and of propriety are also important for public endeavors and an elaborate system of controls helps to ensure this. The public and their elected representatives want to impose certain standards of behavior on those who receive taxpayers' money beyond what is recognized by the commercial code. Some of this concern about fairness involves the government getting a good value for its money. Whereas industry has to accept the fact that sometimes it does not get the best possible price, this is seen in a public environment as the government being overcharged. Who wants to hear that the government paid $10 for something that was sold the next month for $8? Even though this happens to us in our personal lives all the time, we see it differently when it happens with public money. As a result the government has legislated that it will obtain the best price possible and will have access to contractor cost and pricing data to ensure this.

Some of this concern involves industry behavior, particularly regarding corporate perks and policies. For instance, a GAO report on small business overhead turned up meetings at resorts, rental of yachts, T-shirt purchases, sports tickets and liquor purchases, all characterized by a prominent senator as "a pattern of abuse". In commercial transactions, of course, no one cares what the seller does with his money. With public money, however, there is a perception that it is supporting and, hence, condoning such behavior.

The fact that trade-offs exist doesn't mean they aren't worth making. It does mean that change isn't free of cost.

What is Our Experience with Reform?

Because reform entails trade-offs among desirable goals, it is not surprising to find that reforms tend to be cyclical. There are some excellent examples.

Perhaps the classic example in contracting is the trade-off between fixed-price and cost-plus contracts. The department has continuously wavered between the two, drawn to fixed-price contracts because of the incentives they give the contractor, yet stumbling on the high uncertainty in major weapons acquisitions that makes fixed-price terms hard to set. For instance, in the 1950s contracting was dominated by cost-plus contracting in an effort to push technology forward rapidly and gain on the Soviets. In the 1960s this practice fell into disrepute as huge overruns occurred. Secretary of Defense Robert S. MacNamara then instituted Total Package Procurement (TPP), essentially a fixed-price contract for R&D and initial procurement. This sounded like a good idea, but it failed. There was too much risk. TPP contracts on systems like the F-14 and the LHA failed to constrain cost and eventually had to be rewritten. So fixed-price instruments fell into disuse on major systems until the 1980s. At that time the department, under attack for a variety of procurement "scandals," rediscovered the fixed-price contract. Secretary of the Navy John Lehman particularly vowed to "hold the contractor's feet to the fire." Again major acquisitions were put on fixed-price contracts, and again the fixed-price contracts failed for the same reasons: There was too much uncertainty at the early stages of a major procurement to set firm costs and schedules. Indeed, at this writing the department is still in court over the A-12 contract. So a new reform was instituted: no fixed price contracts early on in the acquisition cycle, and that is where policy now stands. But does anyone doubt that the wheel of

reform will turn again and that the department will someday rediscover fixed-price contracts?

Nor is this cyclicality limited to contracting. Live fire testing and truth-in-negotiations were major reforms of the acquisition system in the 1980s. Today their elimination or modification is also considered reform.

The current effort in acquisition reform consists of two elements: revising acquisition laws (the "Section 800" Report) and reducing milspecs. Both are worthy efforts. However, for neither will major reform be easy.

The Section 800 report formed the basis of the recent acquisition reform bill. This report was produced at the direction of the Congress to "streamline the acquisition process" and "eliminate unnecessary laws" while "ensuring continued financial and ethical integrity" and "protecting the best interests of the department." Many provisions involved cleaning up obsolete and unused statutory provisions. It was a worthwhile but low impact effort. However, some provisions had more bite to them, the main ones being the raising of thresholds for socioeconomic laws and a reduction in weapon system testing requirements.

The proposal on socioeconomic laws was fairly modest (to raise the thresholds, not eliminate the provisions) and the argument in favor of doing this was very strong: the thresholds had not changed in many years and so, in real terms, had fallen much below what had been originally intended. Further, the provisions added significantly to the cost and effort of contract administration. However, the beneficiaries of these provisions (unions, small businesses, minority-owned businesses) were reluctant to give up their advantage. They succeeded in modifying some of the proposed changes (Meadows, 1994).

On weapons testing, proponents of an aggressive approach, such as Senators David Pryor and Richard Roth, railed against any weakening of the existing requirements that had been set up in 1983 during an earlier round of acquisition reform. As Pryor wrote,

> Our troops deserve weapons that work. Independent testing of weapons provides the integrity and objectivity needed to achieve this goal. We must preserve and strengthen independent test and evaluation in the high-stakes world of military procurement (Prior, 1994).

As a result of this opposition the department backed off its proposal.

The other major effort in acquisition reform involves making milspecs less onerous and more compatible with commercial specs, thereby allowing greater use of commercial products. It's an important effort and will certainly produce a worthwhile result. Milspecs and milstandards tend to flourish over time, become outdated, become layered, and generally not get the skeptical scrutiny they should get. Without question, periodic pruning is in order.

However, producing significant change will be difficult. Sometimes this effort is characterized as "eliminating boilerplate" from contracts and, while helpful, this alone is unlikely to produce major change. Boilerplate implies language that is added routinely and without much thought, leading one to conclude that if only boilerplate is being eliminated, there'll not be much impact in terms of reform. Of course, one person's boilerplate may be another's critical contract provision. In this case the effort will involve trade-offs, either explicitly or implicitly. As noted earlier, even using commercial specifications often involves trade-offs. And trade-offs are hard. It remains to be seen what kind of trade-offs will be proposed and how they will be received.

What are the Prospects for Reform?

The current administration is deeply sincere about acquisition reform and has both the expertise and the organization to effect real change. But no observer can be wholly optimistic about the prospects.

First, acquisition reform is a very hard problem as everyone knows. Trading off desirable goals is difficult and contentious. The efficacy and validity of any proposed change is usually uncertain while the cost is clear. Further, many of the problems stem from organizational culture and attitudes that are extraordinarily difficult to change.

Second, real reform entails a political cost. Because reform requires trade-offs, there will be "losers" in any reform package. The losers will be unhappy, and must be defeated or persuaded politically. This requires the investment of political capital and no administration has political capital to spare. There are so many higher priorities that an administration might want to focus on that acquisition reform will probably not make the list. However, there is no way to accomplish real reform on the cheap. An acquisition reform package that is low in political costs will also be low in impact.

Third, acquisition reform is a victim of the politics of perception. The widespread dissatisfaction with the current acquisition system, coupled with the difficulty in talking about costs publicly, means that every administration must be seen trying to reform the system, must have an active acquisition reform policy and rhetoric, *even if no real progress is made*. In this, acquisition reform is like many other difficult policy problems; administrations must talk a good game even if no real action is implemented. Aggressive rhetoric gets 80% of the political credit. Real action, with all the political costs involved, is thus unattractive, even unnecessary. Whether consciously or not, therefore, administrations get stuck in the rhetorical stage, stating what they sincerely believe about acquisition reform, but never moving far into the action stage because of the costs involved.

Predictions are always risky. As that great American sage, Yogi Berra, once said: "I never make predictions, especially about the future." Throwing caution aside, however, I will say this: that radical reform of the acquisition system will not happen until it becomes a presidential priority, heard frequently in his speeches. It is the President, after all, who ultimately decides where to fight his administration's battles and on what to spend his political capital. Until that happens, acquisition reform will be a low cost, and hence low impact, effort.

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SOME LONG-TERM ISSUES AND IMPEDIMENTS AFFECTING MILITARY SYSTEMS ACQUISITION REFORM

Edmund H. Conrow

Several approaches have been tried to improve the predictability and control of military systems acquisition, yet costs grow and schedules slip while performance is close to that specified. Cost and schedule growth are generally associated with different government and contractor objectives. An analytical model was created to mirror the military systems acquisition process consistent with statistical results from a broad sample of military programs spanning the 1950s through 1980s.

The management of a major military system acquisition project is an exceptionally challenging task. Given its complexity, the large amounts of money frequently involved, and the political and military consequences riding on the outcomes, it is understandable that considerable attention and effort have been devoted to improving the methods of military systems acquisition management. Over the past three decades, several different acquisition strategies and numerous detailed management approaches have been tried in an attempt to improve the predictability and control of project outcomes. Improvements have been sought, for example, through changes in the types of contracts, the type and extent of competition, the amount of management reporting and review, and the distribution of responsibility between the service project office and industrial contractor. Yet the goal of a predictable and controllable project has proved elusive.

Persistent and widespread cost and schedule growth in U. S. military systems has been documented since the 1950s; in contrast, system performance is typically very close to desired levels. However, no satisfactory theoretical explanation has been advanced to date (1994) to explain this behavior.

While the specific sources of cost, performance, and schedule (C, P, S) difficulty may vary from one project to the next, they

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are generally associated with different preferences held by the government program office and contractors, coupled with a poor understanding of the range of possible outcomes, which themselves are conditioned by program structure. A microeconomic framework is presented in this paper that addresses these issues and models the military acquisition process.

BACKGROUND

Marshall and Meckling (1959) were perhaps the first to identify cost, performance, and schedule as important variables for measuring program success. They evaluated a sample of aircraft and missile programs with equivalent Engineering and Manufacturing Development (EMD) phase start dates in the 1940s and 1950s. They found the average ratio of the most recent and earliest production cost estimates to be between 2.4 and 3.2. [A ratio (change value) > 1 indicates cost or schedule growth or performance degradation.] This corresponds to a 140 to 220 percent increase in cost. They also found the average schedule change to be 1.5 between early estimates of first operational dates and the actual first operational dates.

Commenting on the cost growth and schedule slippage, Marshall and Meckling (1959, p. 17) said:

> Availability (schedule) predictions, like cost predictions exhibit both a decided bias toward overoptimism and substantial variation in the extent of the optimism.

Perry, et. al. (1971) estimated cost, performance, and schedule change ratios for a sample of military programs with start dates in the 1950s and 1960s. They found the average cost, performance, and schedule change to be 1.44, 1.05, and 1.15, respectively.

Dews, et. al. (1979) estimated these same ratios for a sample of military programs with start dates in the 1970s. They found the average cost, performance, and schedule change to be 1.34, 1.00, and 1.13, respectively.

Cost and schedule growth occurred in each of these program samples, but where performance results were evaluated, virtually no change was observed.

Several insightful observations exist in the literature as to the causes of military system cost and schedule growth.

One likely cause was first identified by Marshall and Meckling (1959, pp. 20-21):

> Typically, in weapons development great emphasis is placed on performance. Most new weapons are developed around specific detailed performance requirements laid down by the military—requirements that are taken very seriously. The penalties incurred by the contractors for not meeting performance requirements are more severe than for failure to meet availability schedules or failure to live within original cost estimates. As a result, whenever circumstances dictate a retreat from early plans, it is usually the costs and/or availability that gives ground.

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The government and contractors typically face only weak disincentives for developing unrealistic estimates of program cost and schedule, as identified by Marshall and Meckling (1959, p. 22):

> Contractors are anxious to have their proposals accepted by the military, and the military itself is anxious to have development proposals supported by the Department of Defense and Congress. The incentive to make optimistic estimates is thus very strong. On the other hand, the contractual penalties for having been overoptimistic are generally small.

The acquisition process of U. S. military systems has been distorted in this way for many years. Charles J. Hitch and Roland N. McKean (1960, p. 252) stated it in the following manner in 1960:

> Excessive optimism in drawing up performance specifications can make the development so difficult that it must fail, or take much longer and cost much more than planned, or require a downgrading of the requirements. It is not unusual for weapon system requirements to be so optimistic that several inventions or advances in the state of the art are needed on schedule if the development is to succeed.

The Government Accounting Office (GAO) (NSIAD-93-15, 1993) recently identified several issues that may lead to problems in major weapons acquisition, including: overly optimistic cost and schedule estimates leading to program instability and cost increases; programs that cannot be executed as planned with available funds; and programs being oversold to survive.

The GAO (HR-93-7, 1993) also attempted to identify possible causes for these problems, and stated:

> While there are many reasons for these types of problems, the underlying cause of persistent and fundamental problems in DoD's weapons acquisition process is a prevailing culture that is dependent on generating and supporting new weapons acquisitions.

In summary, distortions in the military systems acquisition process that can lead to considerable cost and schedule growth have been noted for the past 35 years and validated in part by data going back to the 1940s and 1950s.

Each of the above studies has contributed knowledge about military program C,P,S changes and some of their underlying causes. However, a void exists in the literature relative to a mechanism to tie cost, performance, and schedule trends together.

This paper presents a comprehensive microeconomic analytical framework that models the military systems acquisition process. It includes government and contractor preferences; external, programmatic, and technical constraints; factors that influence the program starting point; dynamics that occur during the course of a program; and likely outcomes predicted by the theoretical framework. (The complexity of the underlying microeconomics, organizational behavior and associated differential calculus used to develop the framework has been greatly simplified for this article.)

Microeconomic Framework

In acquiring U. S. military systems, the government and contractor each have a set of objectives regarding the projected C,P,S outcomes. The government generally prefers lower over higher cost and schedule, and higher performance. The contractor

prefers higher cost, performance and schedule. [In this article I focus on interactions at the government program office level. Trade-offs within the government outside the program office are externalities that vary on a case-by-case basis (e.g., lead to funding fluctuations) and are not addressed in this article.]

Lower costs are desirable to the government to develop more military systems for a fixed budget (or the same number for a reduced expenditure). Shorter schedules that enable the system to become operational earlier enhance the force structure and military balance of power. Higher performance permits increased operational capability for the mission.

The government will typically have in mind a maximum program cost and schedule length...

Contractors prefer higher costs because they increase profits. Longer schedules are also desirable to maintain a stable work force and a long-term working relationship with the government, which gives the contractor a potential competitive advantage for follow-on or future contracts. Contractors prefer high performance to improve their potential competitive advantage in the high technology arena that often provides a potential competitive advantage.

The production schedule is generally set by high level government organizations (e.g., the services or Congress), based upon inputs from the project office and contractors (e.g., cost versus lot quantity). Hence, the production schedule can generally be characterized as a constraint externally imposed by higher level government personnel.

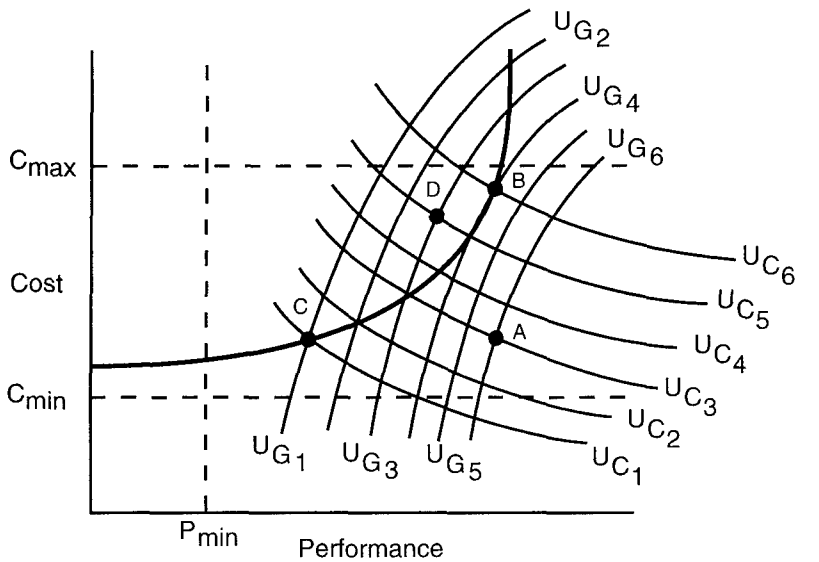
Given the government and contractor preferences, the next step is to consider programmatic and technical constraints associated with cost, performance, and schedule.

The government will typically have in mind a maximum program cost and schedule length, along with minimum performance. The contractor will often have its own minimum cost and schedule length.

A technical possibility surface encompasses the region of feasible C,P,S solutions, and is the technical program constraint. Points on the technical possibility surface or any two-dimensional slice of the surface indicate efficient (but not necessarily optimal) solutions. This is given by points B and C on the C:P possibility curve in Figure 1. (In the microeconomic analysis of two goods this curve is sometimes termed a "production possibility curve." (McCloskey, 1982, p. 500). Points lying above a possibility curve indicate feasible, but inefficient solutions. Those points below a possibility curve indicate an infeasible solution. In Figure 1 for the C:P case (for a given schedule), point D above the curve is an inefficient combination of cost and performance, since the system could be developed at the same cost but with higher performance by moving to the right or at the same level of performance with less cost by moving down.

A point to the right of the C:P curve (A in Figure 1) is infeasible for a given set of input constraints (e.g., manufacturing processes, technology level, program structure) for a given schedule. This point will only become feasible with a shift to the right of the entire C:P curve, thus requiring, for example, improved yield for a given manufacturing process if cost is held constant. In effect, solution point A corresponds to an inappropriate schedule length selected for the specified cost and performance levels.

It is anticipated that the last few percent of the maximum performance possible will lead to increasingly greater program cost and schedule length (the first and second derivatives of cost with respect to performance are positive). This causes a major problem in military systems acquisition where performance near or exceeding the current state of the art is typically specified



Note: 1.) $U_{G_6} > U_{G_5} > U_{G_4} > U_{G_3} > U_{G_2} > U_{G_1}$

$U_{C_6} > U_{C_5} > U_{C_4} > U_{C_3} > U_{C_2} > U_{C_1}$

Where: U_G = government utility, U_C = contractor utility

2.) A = infeasible; B and C = feasible, efficient; and D = feasible, inefficient solution points

Figure 1. Overlaid, Constrained Typical Iso-Schedule Government and Contractor Cost: Performance Utility Curves and Technical Possibility Curve

for new development programs, yet insufficient cost and/or schedule is typically budgeted to achieve the desired level of performance. In fact, such problems are not limited to military programs, affecting commercial technologies and programs as well.

I now present two actual examples of the C:P slice of the technical possibility surface. An exaggerated instance of cost increase for a very minor performance change is given as an illustration in Figure 2. Here, the purchase price of a relatively high performance U. S. commercial 1,389,580 detector element visible charge coupled device (CCD) focal plane array versus performance was examined. The data represents the C:P slice of the technical possibility surface, and the plotted points are feasible solutions. The only pricing criteria for the CCD is the number of defective detector elements (operability as a measure of performance), and as it goes from 20 to zero (for 1,389,580 total elements), the resulting price increases by a factor of twelve. Thus, the last 0.0014 percent of available normalized performance leads to a twelve times increase in cost!

The postulated characteristics of the C:P slice of the technical possibility surface are also evident in an elegant figure developed

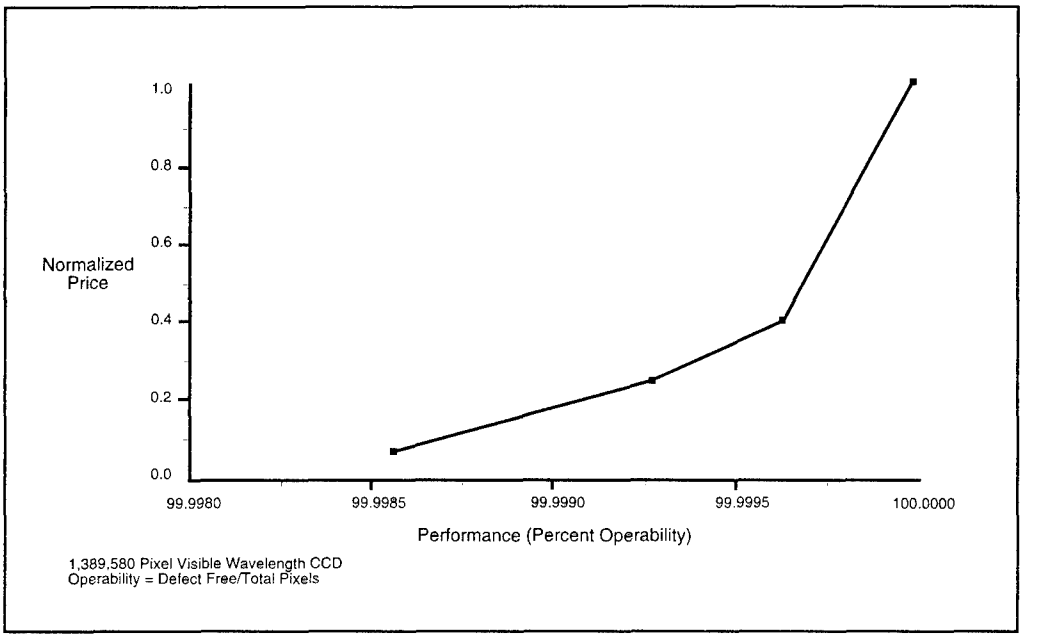


Figure 2. Focal Plan Array Price Versus Performance

by Norman Augustine (1986, pg. 46). The figure includes a number of highly diverse commercial and military items which have similar normalized C:P curve shapes and positive first and second derivatives of cost with respect to performance. These items include: 35 mm camera lenses (focal length versus cost), the salary of baseball players (batting average versus salary), 1960s aircraft (speed versus cost), inertial reference units (drift rate versus cost), diamonds (quality versus cost), machined parts (tolerance versus cost) and radar availability (availability versus spares cost). Augustine states that:

> A disproportionate share of the cost of most purchases is concentrated in a very small fraction of the features sought. So-called "extras" are particularly flagrant contributors to cost in both the commercial and government marketplaces.

From Figure 1, the direction of increasing government utility with respect to C:P is to the southeast (in map coordinates, or down and to the right), while that for the contractor is to the northeast (up and to the right). Several observations can be derived from the government and contractor C:P utility mappings given in Figure 1 using simple microeconomic theory. (See for example: McCloskey, 1982). First, since the government and contractor C:P utility curves form intersections rather than tangencies, no stable solution points are possible in a microeconomic sense. Second, the common direction of increasing utility for the government and contractor is to east (right). Consequently, since both government and contractor utility increases with increasing levels of performance the resulting C:P portion of the program solution point will tend to drift in the direction of increasing performance. A major difficulty for both the government and contractor in this situation is the general lack of knowl-

edge associated with the C:P slice of the technical possibility surface, which forms a technical constraint in terms of the feasible limit of the resulting solution point.

In addition, the government and contractor preferences typically lead to a sub-optimal solution since both parties jointly favor increased performance, but little pressure initially exists to prevent performance from dominating the resulting solution. The adverse cost and schedule of a performance dominated solution are often not recognized until relatively late in development when programmatic or technical constraints become evident—in effect the item cannot be built for the anticipated cost (budget) and schedule to obtain the required level of performance.

For example, in the Minuteman I and Polaris A-1 programs performance was initially the dominant trade variable. Near the conclusion of the development process it became evident that neither missile could initially achieve the ambitious range (performance) requirements due to technical constraints, yet significant political pressure existed to deploy both missiles as early as possible (programmatic constraint). This led to a revised tradeoff between missile performance and schedule (Conrow, p. 113-114).

Both missiles were deployed on time, but with an operating range 20 percent less than initially specified. In the second Minuteman I wing deployed a year later roughly 60 percent of this range reduction had been eliminated, while for the subsequent Polaris A-2 missile deployed a year later the initial range requirement was achieved. In both the Minuteman and Polaris cases, program cost was allowed to increase in order to meet the delivery schedule and the reduced range requirements. Furthermore, since cost, performance, and schedule cannot be traded perfectly (e.g., frictionless) in the short-term, the resulting Minuteman I and Polaris A-1 program cost was likely greater than if the missiles' operating range requirement had initially been 20 percent less than that actually specified.

Knowledge of the technical possibility surface, or even two-dimensional slices of the surface, may be unknown or highly uncertain for key subsystems until late in the development phase or even the production phase. An uncertain technical possibility surface can lead to severe program risk when performance levels approach or exceed the highly uncertain state of the art, particularly when program cost and schedule characteristics are not considered in an unbiased fashion. When ambitious performance requirements are set and the design process is dominated by performance, pressure exists on the government and contractor alike to meet these requirements, even if program cost and schedule are adversely affected as a result.

Government and contractor motivations to start and continue programs initially bias downward both parties' estimates of cost and schedule for a given level of performance, leading—later in the program—to increased cost or schedule in order to meet performance requirements. The issue faced by government and industry is how to adjust their C,P,S goals to be consistent with the technological possibilities that are being revealed to them.

By the time the problem usually is recognized a considerable investment has already been made in the existing system design. Hence, by this time the flexibility to alter the design may be limited, leading to even greater cost or schedule growth than if the true situation had been recognized at the beginning of the program when performance requirements were specified and the C,P,S starting point was set. This results because C,P,S cannot be perfectly traded in the short-run.

Since both government and contractor utility decreases with lower performance, both parties may only reluctantly decrease

performance requirements during development even when the originally chosen solution is infeasible. Hence, an unrealistic C,P,S starting point results in a C,P,S solution point that is not an unbiased or random choice between cost, performance, and schedule, leading to increased cost and schedule, but little decrease in performance.

If the C,P,S solution point lies in the infeasible region, such as point A in Figure 1, resolution of this unsustainable situation requires movement of the solution point to the north with generally increasing cost or schedule (point B, for example), to the west with generally decreasing performance (point C) or a combination of the two (between points B and C). Since the utility of both parties generally decreases with movement towards point C (less performance), this will generally not occur unless it is externally mandated. Hence, program change will tend to be towards the north rather than towards the west, bounded by the technical possibility curve and the resulting solution point will also tend to be inefficient (e.g., lying above this curve, as point D).

...both parties... reluctantly decrease performance requirements during development even when the originally chosen solution is infeasible.

The performance-driven choice process becomes all the more troublesome when the starting point is relatively high up on the technical possibility surface. Such a choice may cause large cost or schedule growth if the C,P,S starting point is unrealistic, particularly if impractical performance requirements are not relaxed. The resulting cost and schedule growth will generally lead to increased contractor profit. Since contractor utility increases with increasing profit, they have little reason to decrease cost and schedule, particularly when in a sole source role late in the development phase.

Is The Evidence Consistent With The Theory?

Five hypotheses resulting from the microeconomic framework were tested and confirmed by a statistical analysis performed on a large sample of historic DoD programs. Statistical analyses of C,P,S change data derived from DoD major weapon systems can help to determine the degree to which historical data are consistent with the microeconomic framework of military systems acquisition.

Three different data sets were obtained for the statistical analysis and combined into an overall data set to increase the statistical sample size. The data sets mostly consisted of aircraft and missile programs (46 of 58 total programs). In addition, the programs contained in the data sets were major development programs rather than follow-on or upgrade programs. The data sets and the number of non-overlapping programs they contain are now discussed.

The Perry et. al. (1971) data set was originally derived from surveys and follow-up visits to various DoD programs: it represents programs with Milestone II (or equivalent) dates in the 1950s (2 programs) and 1960s (18 programs). The Dews et. al. (1979) data set was derived from Selected Acquisition Reports (SARs), and represents programs with Milestone II (or equivalent) dates in the 1970s (8 programs). The Conrow data set was also derived from SARs, and represents programs with Milestone II (or equivalent) dates in the 1960s (7 programs), 1970s (17 programs), and 1980s (6 programs). The overall combined data set (1950s through 1980s) thus includes 58 programs (2 + 18 + 8 + 7 + 17 + 6 = 58 programs) with a total of 48, 52, and 51 programs reporting cost change, performance change and schedule change data, respectively.

The ratio between a "Current Estimate" (CE) produced at one "snap-shot" in time

Table 1. Overall Combined Data Set Summary Statistics (*)

VARIABLE	COST	PERFORMANCE	SCHEDULE
Sample size (programs)	48	52	51
Average	1.26	1.00	1.24
Median	1.16	1.00	1.13
Standard deviation	0.28	0.13	0.30
Minimum	0.86	0.65	0.75
Maximum	2.07	1.42	2.25
Lower quartile	1.06	0.92	1.03
Upper quartile	1.41	1.06	1.44
Skewness	1.24	0.38	1.24

*: Cost, performance, and schedule correspond to cost change, performance change, and schedule change associated with the current program estimate divided by the initial Milestone II (or equivalent) estimate

during a program divided by an estimate produced early in the development phase [known as a "Development Estimate" (DE] was defined for C,P,S as a baseline for these estimates. The DE is typically associated with Milestone II. Milestone II is the decision point to determine whether or not a DoD program will enter Engineering and Manufacturing Development (EMD). Some programs in the sample did not go through a Milestone II review because they pre-dated this particular management scheme. In these cases, an equivalent time, such as the start of the EMD (or equivalent) Phase contract, was used.

The time in the program when a CE was made in the Perry data set spanned a large range from early in EMD to the O&S phase. In the Dews data set, the CE spanned a narrower range from the middle of EMD to the middle of the production phase, but only development phase C,P,S change data was included in the statistical data base for this article. In the Conrow data set the CE represented a point in time near the program IOC date. Only development phase C,P,S change data was included in the data base. Thus, most of the programs in the overall sample represented the EMD (or equivalent) program phase.

Summary descriptive statistics for the overall combined data set are given in Table 1. Sample statistics for all three data sets were quite similar, but since the overall combined data set covers a longer time period (1958-1986) and includes more systems, Table 1 only includes results from this data set. The mean, median, and standard deviation for the cost change and schedule change variables are similar to each other, yet noticeably larger than the corresponding values for the performance change variable.

C,P,S predictions, drawn from the microeconomic framework discussed above, were tested against the statistical results.

First Hypothesis: Because of government and contractor utility preferences, relatively few systems will have significant overall development phase performance degradations. In addition, since many U. S.

military systems have performance requirements set at or beyond the technical feasibility level, relatively few programs will have large gains in performance from the initial estimated level.

The hypothesis cannot be rejected given the mean and median values for the performance change distribution, as well as the dispersal of performance change values around the no change level (1.00). Both the mean and median values for the performance change distribution were 1.00, and only 10 of 52 programs had a slip in performance > 10 percent while only 9 of 52 programs had a gain in performance > 10 percent.

... the variation in performance... is likely to be smaller than corresponding variations in cost and schedule.

In terms of more extreme values, only two of 52 programs had a slip in performance of 25 percent or more, and only one of 52 programs had a gain in performance of 25 percent or more.

Second Hypothesis: Due to a combination of utility preferences and technical feasibility, the variation in performance change for U. S. military systems is likely to be smaller than corresponding variations in cost and schedule.

From Table 1, the standard deviations of changes in cost, performance, and schedule are 0.28, 0.13, and 0.30, respectively. Consequently, the hypothesis cannot be rejected given that the standard deviation of performance change is less than half that of program cost change and schedule change.

Third Hypothesis: Due to a combination of utility preferences and technical feasibility, U. S. military systems will typically exhibit an increase in cost and/or schedule during development.

The hypothesis cannot be rejected given that 43 of 48 programs (90 percent) exhibited cost growth and that 40 of 51 programs (78 percent) exhibited schedule slippage. In addition, a number of programs had large cost growth or schedule slippage. For example, 30 of 48 programs had cost growth (25 percent) and 20 of 51 programs had schedule slippage (25 percent).

Fourth Hypothesis: The shape of the development performance distribution will likely be near-symmetrical, whereas the shapes of the cost change and schedule change distributions will likely be right-hand skewed. This is because the government and contractor strive to meet performance requirements, while typically adjusting program cost and/or schedule to achieve the desired levels of performance. Final performance achievements can be viewed as random variations around the target value.

The hypothesis cannot be rejected given the skewness, mean, and median values for these change distributions in Table 1. A skewness of 0 indicates that the data are symmetrically distributed while a positive value indicates that the distribution has a right-hand skew. From Table 1, the skewness coefficient for the cost change and schedule change distributions is positive and roughly 3.3 times greater than that for the performance change distribution. In addition, the skewness coefficient for the performance change distribution is near zero (0.38).

The difference in the mean and median for the performance change distribution is virtually zero, while that for the cost change and schedule change distributions are 0.10 and 0.11, respectively. These results, as with the skewness results mentioned above, indicate that the performance change distribution is nearly symmetrical, while the cost change and schedule change distributions have a right-hand skew.

The initially infeasible C,P,S solution point that exists for many systems results from a mis-specification of the technical possibility surface due in part to an under-

estimation bias associated with the level of performance that can be achieved for a given level of cost and/or schedule. This together with the primary government and contractor desire to meet performance requirements, while allowing cost and/or schedule to increase during the course of the program to achieve a feasible C,P,S solution point, causes the cost change and schedule change distributions to have means greater than one, as well as a right-hand skew.

Fifth Hypothesis: Given the complex nature of the C,P,S trades that occur during a military program, no simple relationship will likely exist between the Milestone II date and C,P,S change.

There was negligible correlation between cost change, performance change, and schedule change versus the Milestone II date. Consequently, the hypothesis cannot be rejected given the limited correlation between C,P,S change and the Milestone II date.

Discussion

The above results support the contention that various military systems acquisition policy changes instituted by the government have had little success in dealing with the underlying issues discussed above that contribute to program cost and schedule growth.

Although the average cost growth for the overall combined data set is 26 percent, the dollar magnitude of military program cost growth associated with this is substantial.

It was only possible to confidently identify the dollar magnitude of cost growth for the Conrow 30 program data set (of the 48 total programs having cost change data). Initial EMD phase cost estimates for the Conrow data set were compared to actual values recorded following the completion of this program phase.

The resulting total cost growth of this sample was $10.9 billion (FY94). When projected to all military development programs over the past 35 years, including Concept Exploration and Definition and Demonstration and Validation phases in addition to the EMD phase, the resulting total development cost growth is likely between $40 billion and $80 billion (FY94)! (In addition, substantial production phase cost growth has also occurred during this time. Production phase cost growth is often, at least partially, driven by the microeconomic inefficiency of the development phase C,P,S solution point.)

There is typically little or no reward... for identifying relatively high risk items in the early development phase...

While it is easy to identify the cause of performance-related problems in the DoD systems acquisition process, it will be much more difficult to create a paradigm shift to deal with it due to the underlying incentives that are inherent in the institutional structure. Having a set of C,P,S analytic trade tools early in the program design process may aid decision makers in making rational decisions. However, simply possessing viable trade tools will not be sufficient to eliminate the problems discussed above for two reasons.

First, all military programs have C,P,S risk due to an incorrectly specified technical possibility surface, which results from uncertainty in specifying the surface coupled with institutional biases and preferences. Having C,P,S trade tools or risk assessment tools does not guarantee that they will be applied in an unbiased fashion, particularly as the U. S. Air Force Acquisition Process Review Team (1991) and GAO (NSIAD-91-280, 1991) stated, that both the government and contractors routinely underestimate the risk present in military programs.

In the worst case the estimated program risk is intentionally biased downward in an attempt to portray the program in a more favorable light with higher level government personnel. In effect, there is typically little or no reward in most military programs for identifying relatively high risk items in the early development phase and furnishing the information to higher level government personnel, since it increases the odds of adverse impacts on personnel, funding cutbacks, or program cancellation.

Second, the government and contractor decision makers are typically "graded" much more strictly on whether or not program performance objectives are met versus meeting cost and schedule objectives.

Identifying and managing prospective cost drivers and trading-off schedule in an attempt to manage risk is currently required by DoDD 5000.1 (1991), but it is insufficient given the distorted nature of military program cost and schedule versus performance preferences that exist.

...placing equal or near equal emphasis on meeting program cost and schedule, as well as performance objectives, will be necessary...

The wide spread cost and schedule problems caused by the development of performance-driven military systems will not be eliminated by new acquisition trends, such as concurrent engineering and total quality management, unless they are specifically reoriented to address the changes needed to correct underlying government and contractor institutional biases, preferences, and interaction dynamics, coupled with an uncertain technical possibility surface.

In summary, placing equal or near equal emphasis on meeting program cost and schedule, as well as performance objectives, will be necessary in order to eliminate the strongly ingrained government and contractor program management bias favoring performance that has existed for at least the last 35 years in U. S. military systems. This is particularly important given the substantial dollar magnitude associated with cost growth during this time. No appreciable change in program outcomes is likely to occur without a re-oriented C,P,S emphasis.

The economic theory and statistical results in this paper directly address government and contractor preferences, interactions, and outcomes for the United States DoD systems acquisition process. The same preferences, interactions and outcomes also exist for highly classified ("Black") programs, as well as NASA space programs, given the structure of their acquisition process. For example, the GAO (NSIAD-93-78, 1993) found "no major difference between the cost, schedule, and performance results of the special access acquisition programs it sampled and those of non-special access DoD programs". The GAO (NSIAD-93-97, 1993) also found considerable cost and schedule growth for mature NASA space vehicle programs. Similar preferences, interactions, and outcomes also likely exist for performance-driven large-scale civilian programs (e.g., megaprojects) (Merrow, et. al, 1979, and Myers and Shangraw, 1986).

The economic theory presented in this paper can be adapted to represent the military or commercial systems acquisition process of other countries. For example, the microeconomic framework has been applied to the former Soviet Union military systems acquisition process. Extension of the microeconomic theory to predict likely systems acquisition outcomes for other countries, such as Japan or Sweden, can be readily accomplished given a modest amount of information.

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TECHNOLOGY APPROACH: DoD VERSUS BOEING (A COMPARATIVE STUDY)

A. Lee Battershell

This is an analysis of different approaches in the use of technology by Boeing and DoD to determine how they may have affected development time for the C-17 and the Boeing 777. Boeing's focus on cost, schedule, performance, and market competition is contrasted to DoD's focus on performance. The paper concludes that the mere existence of a technology should not obscure (a) the impact its maturity may have on program cost and risk, (b) whether it will meet a real need of the user as opposed to a gold plated one, and (c) whether the added development time it may require could pose unanticipated problems for the customer, or even result in fielding an obsolete weapons systems.

> The advantage we had in Desert Storm had three major components. We had an advantage in people, an advantage in readiness, and an advantage in technology... We need to preserve that part of the industrial base which will give us a technological advantage... (William Perry, Secretary of Defense) (Mercer and Roop, 1994).
>
> ...technology must earn its way on to a Boeing [commercial] plane... In short, our R&D efforts will continue to be customer-driven, not technology-driven (Philip Condit, Boeing president, 1994).

What are the differences in the way private industry and Government approach technology when developing planes? Why does the Government take longer than the private sector to develop a plane?

There's a perception that high technology included in military planes contributes significantly to the typical 11 to 21 years (DiMascio, 1993) it takes the Department of Defense (DoD) to develop, produce, and deploy new military aircraft. To learn if it is the technology that takes so long, this study explores the way Boeing and DoD approached technology in developing the Boeing 777 and the military C-17. One reason for selecting the C-17 is that it does not have the complex weapons systems inher-

ent in fighters or bombers, and yet it still took more than 14 years to develop and deliver. In contrast, it took little more than four years to develop and deliver an operational Boeing 777.

What is Technology?

According to Webster's Dictionary, technology is defined as "...an applied science that includes the study of industrial arts one can apply toward practical use" (Guralnik, 1980). Technology is a method or process for handling a specific technical problem. By contrast, natural science is: ...the study of knowledge to understand the nature of the subject matter which is being studied. Its purpose is for the sake of understanding—the application or usefulness may not be self evident at that time. Technology is the application of scientific breakthroughs (Goldberg, 1995). When one speaks of a technology breakthrough, one is defining a new process or method for application of a scientific breakthrough.

Need For Change

The Department of Defense is coping with reduced resources and a changing world. At home, the American public continues to demand that its government become more efficient, prompting Vice President Al Gore to initiate a National Performance Review to: "...make the entire federal government both less expensive and more efficient, and to change the culture of our national bureaucracy away from complacency and entitlement toward initiative and empowerment..." (Gore, 1993).

The late Secretary of Defense Les Aspin directed a "Bottom-Up Review" of DoD to identify cost savings and improve efficiency and effectiveness. In his final report Aspin said: "We must restructure our acquisition system to compensate for the decline in available resources for defense investment and to exploit technological advances in the commercial sector of our economy more effectively..."(Aspin, 1993).

Studies of DoD acquisition over the past 25 years reveal that (a) DoD's way of doing business resulted in programs that spanned 11 to 21 years (DiMascio, 1993), and that (b) by the time the weapon systems were finally delivered the technology was outdated. Significantly, the lengthy time to develop weapon systems was also directly linked to a doubling of the costs originally planned (Gansler, 1989). Based on this past performance one might expect higher costs in the future. Unfortunately, the ongoing process of federal deficit reduction rules out increased military spending. DoD must learn not only to maintain the technological superiority of the American military, but learn to do so in less time and at less cost.

Assumptions

Jacques Gansler warned against DoD's continuing preoccupation with technology without consideration of cost. Substitute schedule for cost, and one could say the same is true for time. As Gansler writes:

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> Until the DoD introduces affordability [and schedule] constraints into its requirements process and shifts from a design-to-performance approach to more of a design-to-cost [and design-to-schedule] approach, it will procure fewer and fewer weapon systems each year, and eventually the United States will not have enough modern systems to present a credible defense posture (Gansler, 1989). *[parenthetical material added to original]*

It should not take 21 years to develop and deliver a weapon system nor should advanced technology cost as much as it does. Gansler points out that performance has improved in commercial as well as the defense industry because of technology, "...however, in the defense world costs have risen along with performance." Comparatively, "...commercial computers, televisions, and other items that use similar technology have improved dramatically in performance and gone down dramatically in price," (Gansler, 1989) and don't take as long to produce.

Methodology

This paper is a comparative analysis of the way Boeing and DoD used technology. The problem was to determine whether a difference in DoD's approach to technology contributed to the length of time it took to develop the C-17. This study is based on written works (published and unpublished), interviews, and observances.

Research for this report was primarily focused on the DoD C-17 and the Boeing 777. It included an extensive review of literature and interviews. The literature review encompassed studies, laws, standards, and articles relating to various approaches to technology, their focuses and parameters. The interviews were conducted with individuals who were or had been involved with the Boeing 777 or the Office of Secretary of Defense (OSD). Additional conversations with senior leaders at Boeing, the Air Force, and DoD revealed their approaches to technology use and their perceptions.

The Boeing Approach

> The 777 causes me to sit bolt upright in bed periodically. It's a hell of a gamble. There's a big risk in doing things totally different. (Dean Thornton, President, Boeing Commercial Airplane Group, 1992) (Main, 1992)

> Boeing professed a belief that one must approach technology with an eye toward utility...it must earn its way on... (Condit, 1994)

Boeing's conservative approach was illustrated in the 1970s and 1980s when it decided not to include in its 767 more advanced systems such as fly-by-wire, fly-by-light, flat panel video displays, and advanced propulsion systems (Holtby, 1986). Even though the technology existed, Boeing did not believe it was mature enough for the 767. Boeing also used what Gansler defines as a design-to-cost constraint. After Boeing defines a program it evaluates cost before going into production. Its cost evaluations include trade offs of performance, technology, and manufacturing investments (Boeing undated).

In the 1990s Boeing included in its 777 (a) fly-by-wire, (b) advanced liquid-crystal flat-panel displays, (c) the company's own patented two-way digital data bus (ARINC 629), (d) a new wing the company advertised as the most aerodynamically efficient airfoil developed for subsonic commercial aviation, (e) the largest and most powerful engines ever used on a commercial airliner, (f) nine percent composite materials in the

airframe, and (g) an advanced composite empennage (Mulally, 1994). Boeing also invested in new facilities to test the 777 avionics (Proctor, 1994), and to manufacture the composite empennage (Benson, 1995). Did Boeing push the technology envelope for the 777? Philip Condit, Boeing president, said those were technology improvements, not technology breakthroughs. He used fly-by-wire technology to illustrate:

> Fly-by-wire is interesting and you can isolate it. But if you step back, our autopilots are fly-by-wire and always have been. We've given it a little bit more authority [in the 777]. The 737 right from the start had what we called a stick steering mode in which you moved the control wheel to make inputs to the auto pilot. Fly-by-wire. The 757 Pratt Whitney engine was completely electronically controlled... it makes neat writing, but it's not an order of magnitude change. Designing the airplane with no mock-up and doing it all on computer was an order of magnitude change (Condit, 1994).

One only has to review the history of airplane technology during the 1980s to see that Condit is right. Airbus and McDonnell Douglas included fly-by-wire on the A340 (Nelson, 1994) and the C-17, respectively, during the 1980s, and both experienced problems. Boeing was able to learn from the mistakes of Airbus and McDonnell Douglas (Woolsey, 1994), and it had the advantage of using new high-powered ultrafast computer chips that increased throughput. In fact Honeywell, the company that McDonnell Douglas dismissed because it couldn't produce the fly-by-wire fast enough for the C-17, was the company that successfully installed it on the 777 (Woolsey, 1994)—but not without problems.

Boeing could not assemble and integrate the fly-by-wire system until it solved problems with the ARINC 693 databus, the AIMS-driven Flight Management System, and the software coding. Solving these problems took more than a year longer than Boeing anticipated. In order to maintain its schedule, Boeing did as much as it could without the complete system, then it used red-label[1] systems during flight tests. Finally, the Federal Aviation Administration (FAA) certified the last link, the primary flight computer, in March, 1995. In April, 1995 the FAA certified the 777 as safe (Acohido, 1995).

Technical Problems

While Boeing may not define its 777 avionics problems as pushing the technology envelope, Boeing did push the envelope on its design and manufacturing process, and its propulsion. As Condit said, "Designing the airplane with no mock-up and doing it all on computer was an order of magnitude change." When one is the first to use a technology in a new way, one can expect problems. Assuming that Boeing is conservative in its approach, one must ask why Boeing went from computer design to build with no mock-up, and why it used new, large, high-performance engines.

Computer and Aircraft Design

CATIA (Computer assisted three-dimensional interactive application) is the computer application that Boeing used to design the 777 and improve its manufacturing process (Benson, 1994). Jeremy Main best described the reasons Boeing changed

[1] A red-label system signifies that the system is still in the development and testing phase. A black-label system signifies that hardware and software are finished and ready for production.

its way of design and manufacture using CATIA in his article, *Betting on the 21st Century Jet*.

> ...as a designer, Boeing is preeminent... I have great respect for them, but they have a long way to go in manufacturing. Therefore, to stay on top, Boeing must find ways of building planes better. If Boeing's new approach to design works, the 777 will be an efficient, economic plane with a lot fewer bugs than new planes usually have. As a result, Boeing could save the millions it usually spends fixing design problems during production and after the plane has been delivered to the airlines (Main, 1992).

Boeing's decision to use CATIA in conjunction with a team concept emerged primarily as a means of cutting costs after analysis revealed that the predominant cost drivers were rework on the factory floor and down-stream changes. The teams that Boeing calls design/build teams include representatives from nearly every Boeing function involved in producing the transport, plus customers and suppliers (O'Lone, 1991).

Typically, engineers were still designing when manufacturing began, and they kept making changes as problems subsequently came to light on the factory floor, on the flight line, and even in the customer's hands after the plane was delivered. For example, when Boeing delivered the 747-400 to United in 1990, it had to assign 300 engineers to get rid of bugs that it hadn't spotted earlier (Main, 1992). United was not happy with Boeing's late delivery of the 747, nor with the additional costs the airline sustained in rescheduling flights and compensating unhappy customers as a result of maintenance delays. Boeing was deeply embarrassed by delivery delays and initial service problems of its 747 (Proctor, 1994). After a lot of research and deliberation, the company decided to use computer aided technology more extensively and change its design and manufacturing approach in order to improve its service. Yet, even though CATIA and the team approach eventually proved worthwhile, there were problems.

Boeing encountered problems in adjusting to 100 percent computer-aided aircraft design. Not only was this a technology change, it was a cultural change. Condit said engineers were reluctant to let others see their drawings before they were 100 percent complete (Condit, 1994). Ronald A. Ostrowski, Director of Engineering for the 777 Division, said one of the initial challenges was to:

> ...convert people's thinking from 2-D to 3-D. It took more time than we thought it would. I came from a paper world and now, I am managing a digital program (Woolsey, 1994).

The software also had problems and development costs ballooned slightly over budget because of CATIA. Boeing CEO Frank Shrontz said "It was not as user friendly as we originally thought" (Woolsey, 1994).

CATIA and design/build teams were new methods for applying technology that pushed the envelope and could have impacted Boeing's delivery schedule. Instead of allowing a possible schedule slip and late delivery to its United customer, Boeing decided to apply more resources, spend the extra money, overcome its problems, and deliver its 777 on schedule. While Boeing did not state how much it spent, in April 1992 Fortune analysts identified $3 billion (Main, 1992) set aside for research and development (R&D) for the 777. In April 1994, an editorial in Aviation Week and Space Technology estimated that final R&D costs for the 777 approached $5.5 billion

(AW&ST, 1994). Based on the analysts evaluations one could conclude that actual R&D costs were approximately $2 billion over planned costs. But, as Alan Mulally, the Senior Vice President for Airplane Development and Definition said:

> In our business it's very rare that you can move the end point... When you make a commitment like we made they [United] lay out their plans for a whole fleet of airplanes so it's a big deal. They'll have plans to retire old airplanes. We could have stretched it out but it just seemed best to us to keep the end date the same and add some more resources (Mulally, 1994).

The wisdom of Mulally's decision was proven a thousand times over. The wing assembly tool built by Giddings & Lewis in Janesville, Wisconsin, and the world's largest C-frame riveting system built by Brotje Automation of Germany, were both run in Seattle on programs generated by the CATIA (Benson, 1995). Engineers designed parts and tools digitally on CATIA to verify assembly fit. In Kansas, Boeing's Wichita Division built the lower lob, or belly, of the 777s nose section using CATIA and digital preassembly. In Japan the skins of the airframe were built using CATIA generated programs. Workers at all plants marveled at the way all the parts built by different people all over the world fit together with almost no need for rework (Benson, 1995). Charlie Houser, product line manager at Wichita, said it best:

> CATIA and digital preassembly let us find areas of potential interference before we started production. The individual assemblies fit together extremely well, especially the passenger floor. That assembly includes composite floor beams, and it went together smoother than any floor grid of any size that we've ever built in Wichita (Benson, 1995).

Engines

Three top companies will supply engines for the Boeing 777: Pratt & Whitney, General Electric, and Rolls Royce. The aircraft was designed for two engines that are billed as:

> ...the largest and most powerful ever built, with the girth of a 737's fuselage and a thrust, or propulsive power, of between 71,000 and 85,000 pounds compared with about 57,000 pounds of the latest 747 engine. Key factors in this performance are new, larger-diameter fans with wide-chord fan blade designs and by-pass ratios ranging from 6-to-1 to as high as 9-to-1. The typical by-pass ratio for today's wide-body jet engines is 5-to-1. Pratt & Whitney is furnishing the PW4000 series of engines, General Electric is offering the GE90 series and Rolls-Royce is offering the Trent 800 series of engines (Donoghue, 1994).

Boeing's success at getting these three companies to produce engines never before produced represent a dramatic change from the time when the federal government was the leader in technology. For example in the 1960s General Electric didn't want to risk the cost and time to develop a high-bypass jet engine for the 747. General Electric was content to let a military development program, the C-5A, absorb the cost and time associated with enhancing high-bypass jet engine technology (Newhouse, 1982). For the 777 Boeing not only pushed for new, more powerful engines, it also pushed for early approval from the Federal Aviation Administration for the plane to fly over oceans (called ETOPS: extended-range

twin-engine operations) (Mintz, 1995).

Normally, the FAA first certifies a twin-engine plane for flights of not more than one hour from an airport, then two hours, and finally, after a couple year's service, a full three hours so the plane could fly anywhere in the world. The 767, powered by Pratt & Whitney JT9D-7R4D/E turbofan engines, became the first Boeing twin to win 120-minute approval in May, 1985, but not until after it had flown for two years (Woolsey, 1991). Jerry Zanatta, Director, 777 Flight Test Engineering, pointed out that engines are so reliable today an airplane could travel on only one engine. Flying with two engines allows redundancy that a pilot wants in order to ensure safety of flight. Flying with more than two engines only increases fuel cost and operating costs unnecessarily. (Zanatta, 1994)

Why did Boeing push propulsion technology? The answer is competition. Boeing's customer airlines are concerned about operating costs and a two-engine plane costs much less to operate than a three- or four-engine plane. Boeing's competition, Airbus, has a twin-engine plane (A330) (Duffy, 1994) that competes favorably with the 777. If Boeing can't deliver, the Airbus can. Still, producing a new engine was not without its problems. For example the Pratt and Whitney engine had performed perfectly in the testing laboratory; but on its first test flight in November, 1993, it backfired several times.

The engine backfired because of differences in the rates of thermal expansion between the interior components of the engine and the compressor case. The case expanded faster than actively cooled interior engine components creating a space between the blades and the case. After the first flight, engineers changed the software commands that direct the variable blade angle of the first four compressor stages to reduce the temperature of the air inside. On the next flight the engine worked perfectly (Kandebo, 1993).

Summary of the Boeing Experience

Boeing looked at its investment in the 777 and its manufacturing process from a tactical and strategic view. It was committed to a successful 777 that would serve its customers and protect its market share against competition for 50 years into the future. Boeing was also committed to changing and improving its manufacturing process using the power of computers so it could improve quality and cut costs well into the 21st century. As a result Boeing management and its Board of Directors were focused on what they had to do to make it all happen. They were willing to commit Boeing resources toward overcoming potential challenges that included computer and process technology.

When Boeing underestimated the challenge of the design-build concept using CATIA, it could have stretched the schedule to spread additional costs over a longer time period. But that would have meant missing the delivery date to United for the first 777. Boeing management made a conscious decision to continue and learn on its first block of 777s so that all future aircraft could benefit.

> We could have stretched it out, but it just seemed best to us to keep the end date the same and add some more resources (Mulally 1994).

The DoD Approach to Technology

> Technology on the C-17 was not as well defined as some would have us believe (Brig.Gen. Ron Kadish, 1994).

> I was shocked in the Fall of 1992 to discover that this airplane was being produced from paper, that they did not have a CAD/CAM system. That

> they had never had a CAD/CAM system (Gen. Ronald Fogleman, 1995).

Secretary of Defense Harold Brown justified using a fixed-price incentive contract to produce the C-17 for two reasons: (a) Congress and President Carter wanted to eliminate cost-plus contracts in order to reduce excessive overruns (Hopkins, 1993), and (b) all the technology for the C-17 was already proven. The Advanced Medium STOL Transport (AMST) prototypes proved short-field take off and landing (STOL) could work and all hardware and software was off-the-shelf (Smith, 1993). The Air Force request for proposal stated that "...Undue complexity or technical risk will be regarded as poor design..." (Johnson, 1986). After McDonnell Douglas won the competition, this theme was carried over into the C-17 technical planning guide:

> The C-17's systems are straightforward in design, are highly reliable, and represent current technology. For example, a version of the C-17's engine has been proven in commercial airline service since 1985. New-technology systems, like the onboard inert gas generating system (OBIGGS), are used only where they offer significant advantages over previous methods....Avionics and flight controls that include computer-controlled multifunction displays and head-up displays enable the aircraft to be flown and all its missions accomplished with a flight crew of only two pilots and one loadmaster (McDonnell Douglas, 1993).

However, the C-17 experience revealed what studies conducted during the AMST had proven and Kadish had pointed out—"the technology was not as well defined as some would lead us to believe." Although McDonnell Douglas did not develop new technologies for the C-17, the way in which the technologies were used was new. The C-17 was a new cargo airlifter dependent on a complex integrated avionics system to reduce the aircrew size to two pilots and a cargo loadmaster. By comparison the C-141 and the C-5 use two pilots, a navigator for tactical and airdrop missions (C-141 only), two flight engineers, and two cargo loadmasters when carrying passengers (Moen and Lossi, 1995). Also, using STOL capability on a plane expected to fly 2,400 nautical miles (NM) with a 172,200-pound payload to include outsized cargo was much different than using STOL on a plane expected to fly a 400-mile radius with a 27,000-pound payload. The plane would require a new wing and, as John Newhouse points out in his book, *The Sporty Game*, "...there is more technology in the wing than in any other part of an airframe...production schedules are keyed to wings" (Newhouse, 1982). The differences in design between a tactical STOL and a strategic STOL were the catalysts that caused schedule slips and cost money.

Advanced Medium STOL Transport

The AMST was the genesis for the C-17. In 1971 the Air Force contracted both Boeing and McDonnell Douglas to build a prototype that, in the words of Gen. Carlton, was "really a miniature C-5" (Kennedy, undated) to transport cargo in-theater. The plane was to fly a 400 NM radius mission, carry 27,000 pounds, and land on short runways using short landing and take-off (STOL) technology. McDonnell Douglas' YC-15 and Boeing's YC-14 prototypes successfully demonstrated powered lift technology in 1975 that met mission requirements (Kennedy, undated). In March, 1976, the Air Force Chief of Staff Gen. David C. Jones asked Air Force Systems Command to see if it was possible to use a single model of the AMST for both strategic and tactical airlift roles,

and if it was possible to develop non-STOL derivatives of the AMST prototype to meet strategic airlift missions (Jones, 1976). It appears that this strategic study originated with a note from the Chairman of the Joint Chiefs of Staff, Gen. George S. Brown, that asked "Is it practical to have an AMST with a slightly higher box pick up much of the C-5 outsized load for Europe—with air refueling as necessary?" (Lemaster, 1976).

Gordon Taylor and Gordon Quinn from the Aeronautical Systems Division at Wright Patterson Air Force Base, Ohio, were leaders in a conceptual design analysis to determine if DoD could use the AMST for strategic missions. The analysis included reviewing the ability to carry the M-60 Main Battle tank, weighing 110,000 to 117,000 pounds, on a routine basis with ranges from 2,000 NM, 3,000 NM, and 4,000 NM. Taylor and Quinn concluded that using a derivative aircraft in a routine strategic airlift role would increase AMST weight and cost significantly. To restructure the AMST from a tactical to a strategic program would require full-scale development (a larger wing, heavier structure, and different aerodynamics). Even in a non-STOL capacity the wing was the major airframe component that the study said must undergo considerable change (Taylor and Quinn, 1976). In May 1976, Brig.Gen. Philip Larsen, Deputy Chief of Staff, Systems, Air Force Systems Command, wrote:

> It would not be cost effective to incorporate a STOL capability in a strategic airlift derivative aircraft. A strategic derivative could employ a less complex conventional flap system which would permit CTOL [conventional takeoff and landing] operations from an 8,000 foot hard surface runway under sea level standard day conditions. The aircraft would be stretched eight feet to provide a 55-foot-long cargo compartment. This would permit routinely carrying the M-60 tank and single item payloads up to 112,500 pounds, or 14 463L cargo pallets, for distances up to 3,000 NM without refueling. In this particular example, it would be necessary to increase... YC-15 wing area 69 percent and gross weight 115 percent... (Larsen, 1976).

On December 10, 1979, Program Management Directive (PMD) No. R-Q 6131(3) formally cancelled the AMST program. On that same day PMD No. R-C 0020(1) provided formal direction and guidance for activities leading to Full Scale Engineering Development of the C-X. PMD R-C 0020(1) directed that the C-X skip Milestone I and the Demonstration and Validation phase because "...the new aircraft will use existing technology... since the Air Force had demonstrated and proved advanced technology concepts and operational utility in the AMST program" (Johnson, 1986).

Changing Payload Requirements

Payload requirements changed at least five times over the life of the C-17. Beginning in 1981 the request for purchase asked for a STOL plane that could carry a payload of 130,000 pounds (AMC, 1993). McDonnell Douglas claimed it could produce a STOL plane that could carry 172,200 pounds 2400 miles (Johnson, 1986). When the contract was awarded in 1982, the payload requirements were changed to 172,200 pounds (AMC, 1993). DoD did not evaluate the cost to grow from a payload of 130,000 pounds to 172,200 pounds. In 1988 DoD changed the payload requirement from 172,200 pounds to 167,000 in order to accommodate the addition of a 4-pallet ramp and OBIGGS that added 5,000 pounds additional weight to the aircraft (Snider, 1992). In 1991 Gen. Hansford Johnson, MAC Commander, reduced the

payload requirements from 167,000 pounds to 160,000 pounds because the kinds of equipment MAC needed to haul over essential routes—from West Coast bases to Hickam AFB, Hawaii, and from East Coast bases to Lajes airfield in the Azores—did not require a plane with a 167,000-pound capacity. He said:

> This was not a reassessment of requirements as much as it was a refinement of the original requirements... McDonnell Douglas, in competing for the contract, offered more than what MAC needed....All of us, being eager to do more, said sure, we'll write the specs at the higher level (Morrocco, 1991).

In January 1995, DoD, Congress, and McDonnell Douglas agreed to decrease the payload requirement even more. If the C-17 were to carry a 160,000-pound payload using short-field take-off and landing capability with the weight of the plane and the required fuel, it needed more powerful engines. Pratt & Whitney and Rolls Royce, had produced more powerful engines, but the Under Secretary of Defense for Acquisition, John M. Deutch, said changing to more powerful engines was too costly. He preferred to reduce payload specifications rather than change engines, especially since the C-17 did not need to carry a greater payload to perform its mission (Morrocco, 1994). Fogleman said that DoD "...allowed the plane to be over spec'd unnecessarily.... We didn't need a plane to carry a 172,200-pound payload then and we don't need a plane to carry 160,000 pounds now" (Fogleman, 1995).

> An absolute critical leg for us in this new world we are living in is how much can this airplane carry 3,200 miles...we established a 110,000-pound payload threshold at the 3,200-mile range... The original requirement set in the early 1980s was for a 130,000-pound payload, the weight of an M-1 tank then....this specification is now not considered the most critical. It was linked to the Cold War goal of transporting 10 Army divisions to Europe in 10 days, rather than how to deal with the types of regional contingencies the Pentagon now is focusing on in its planning. An absolute critical leg for us in this new world we are living in is how much can this airplane carry 3,200 miles.... So we established a 110,000-pound payload threshold at the 3,200-mile range which did not exist before...the aircraft meets that goal and is projected to exceed it. Sticking to the original specification would have required switching to more powerful engines (Morrocco, 1994).

On January 17, 1995, the Air Mobility Commander, Gen. Robert Rutherford, declared the C-17 a success when he certified it operationally capable (McDonnell Douglas, 1995). It's worth noting, however, that the program did not begin to overcome technology problems until after top-level commitment was apparent from principals like Deutch (Defense Week, 1995) and Fogleman. Fogleman essentially said this is nonsense, "...we don't need that much payload capability..." (Fogleman, 1995), and Deutch arranged a settlement with McDonnell Douglas that allowed performance trade-offs and help with computer (CAD/CAM) technology. McDonnell Douglas, in turn, put their best people on the job to produce a technically proficient airplane (Morrocco, 1994). As a result of technology trade-offs and top management commitment from both DoD and the contractor, the C-17 exceeded its schedule during 1994 and met mission

requirements in 1995.

Technical Problems

One might say that design problems and planning problems were at the root of technical problems that added time to development of the C-17. The underlying problem was that the players underestimated the technical challenges. Roger A. Panton, Chief of Engineering at the C-17 System Program Office at Wright Patterson AFB, said "Our primary technical problem with the C-17 was integration. We grabbed too much off the shelf and tried to put it together" (Panton, 1994). Critical off-the-shelf technology included fly-by-wire, advanced materials, engines, software, and the powered lift that the McDonnell Douglas YC-15 prototype demonstrated in 1975.

The Defense Science Board added in a December 1993 report that lack of computer aided design and engineering changes contributed to production delays (Defense Science Board, 1993). Deutch summarized some of the most glaring weaknesses as: (a) technical risks involved in flight test software and avionics integration; (b) structural deficiencies in the wings, flaps and slats; and (c) uncertainty of flight test program requirements (Morrocco, 1993).

Avionics Integration

> Avionics is a term that covers the myriad of ultrarefined electronic devices on which modern airplanes rely... (Newhouse, 1982).

On the C-17 that includes the flight control system and the mission computer. Integration of the mission computer and electronic flight control system was one of the three critical paths leading to first flight (Smith, 1990). The first test flight of the C-17, September 15, 1991, was behind schedule (Smith, 1991) because of problems that included changing from a standard mechanical flight control system to a quadruple redundant electronic flight control system, and delays in the mission computer software and flight control software (Hopkins and De Keyrel, 1993).

In 1987, after McDonnell Douglas missed delivery of the first test aircraft, DoD reduced funding during budget reductions and moved delivery schedule for the first test aircraft three years to the right (to July, 1990) (Mastin, 1994). In addition, in January 1988, Congress deducted $20 million from the C-17 during its budget review, but invited DoD to ask for reprogramming of funds (SAF/AQ, 1989). DoD declined.

Flight Control System

McDonnell Douglas changed to an electronic flight-control system to prevent the plane from entering into a deep stall (Hopkins and De Keyrel, 1993). Wind tunnel testing revealed that the C-17 design caused deep stall characteristics. In 1987 the Sperry Corporation (the flight-control subcontractor) told McDonnell Douglas that the mechanical flight control system could not prevent pilots from putting the airplane into an irreversible stall (ASD/AF/C-17, 1987). After confirming that the aircraft configuration and the mechanical flight control system could allow the aircraft to enter an uncontrollable stall during certain tactical maneuvers, Douglas directed Sperry to change the mechanical flight control to a fly-by-wire system (Smith, 1993). During this same period Honeywell, Incorporated, purchased the Sperry Corporation.

In June 1989, Honeywell officials established April 25, 1991, as the new delivery date for flight qualified software. The additional delay added four years from the time Douglas first asked for the system change until delivery (1987-1991). Even though Honeywell successfully completed an interface control document (ICD) in July 1989, showing how the electronic flight control system (EFCS) interacted with subsystems, the additional delay was too much. Brig.Gen.

Michael Butchko, Air Force C-17 Program Manager, convinced Douglas Aircraft to hire General Electric (GE) for development of a similar system as a precautionary measure (Hopkins and De Keyrel, 1993). Douglas ended Honeywell's contract for the EFCS in July 1989 (Thomas, et al., 1990). GE delivered the version 1 software for integration testing in October, 1990 (Thompson, 1991).

Mission Control Computer

The three mission computers receive data from other systems, analyze data, perform calculations, and display information to the pilot and copilot. The computers act as the heart of the automated avionics system and perform functions normally done by the flight engineer such as determining an estimate of position and velocity, weight limits, airdrop, small airfield approaches, and system management (Thomas, et al., 1990). Each mission computer performs its calculations and then compares its results with the solutions broadcast over the data bus by the other two computers (McDonnell Douglas, 1993).

Douglas awarded a firm-fixed-price contract to Delco in July, 1986, to develop the mission computer (Mundell, 1990). In August 1988, an independent review team that included personnel from McDonnell Douglas, Hughes Electronics, and the Air Force concluded that Delco had not adequately accomplished system engineering and that McDonnell Douglas had not adequately defined the mission computer system requirements. Delco developed the mission computer software enough to hold a critical design review of the detail design in April, 1989 for the first of two increments of software, but it would not commit to a plan for completing the mission computer. In July 1989, Douglas and Delco signed an agreement that partially terminated Delco's contract for the mission computer subsystem, and Douglas assumed responsibility for managing the overall software development effort (Thomas, 1990).

McDonnell Douglas subcontracted a majority of software for the C-17 to subcontractors and suppliers. During this process Douglas did not specify a specific computer language, which resulted in software for the C-17 in almost every known language of the time (AW&ST, 1992). Integration of the software was a nightmare that GAO said resulted in "...the most computerized, software-intensive aircraft ever built, relying on 19 different embedded computers incorporating more than 80 microprocessors and about 1.3 million lines of code" (Hopkins and De Keyrel, 1993). The final software release was in September, 1994 with upgrades through March 1995. David J. Lynch, in his article "Airlift's Year of Decision," said that in 1994 the mission computer remained slow and did not meet the desired throughput capacity requirements (Lynch, 1994). John Wilson, C-17 Deputy Program Manager, acknowledged that the program office needs to consider software improvements:

> This is a tough area. The C-17 System Program Office recognizes that additional throughput could be beneficial. Although the computer performs the basic mission, it is slow and does not meet the desired throughput capacity. We are working the area (Wilson, 1995).

Wings

The wings, flaps, and slats combine with high thrust engines and the electronic flight control system for short take-off and landing (STOL). Exhaust from the jet engines force air over wings and flaps, generating additional lift. Engines on the C-17 are mounted under the wings and large flaps protrude down into the exhaust stream. The engine exhaust is forced through the flap and down both sides of the flap, creating significant added lift. The externally blown flap system and the full-span leading edge

slats enable the C-17 to operate at low approach speeds for short-field landings and for airdrops (Henderson, 1990). Powered lift enables the C-17 to land on shorter runways than current, large-capacity transports by allowing it to fly slow, steep approaches to highly accurate touchdown points (McDonnell Douglas, 1993). In October 1992, the wing failed a wing-strength test (Morrocco, 1993). Even though Air Force had reduced the maximum payload requirements in December, 1989 from 167,000 pounds to 160,000 pounds at 2,400 NM, the wings were still not strong enough to handle a full payload (GAO, 1994) along with the fuel and structure weight at a 1.5 safety factor. Causes of the failure included a computational error in the initial design, optimistic design assumptions, and the method used to determine compression stress (Huston, et al., 1993). The wing modifications covered a large area because McDonnell Douglas used the erroneous computation throughout the wing structure (Smith, 1993).

The failed strength test was preceded by persistent fuel leaks around the wing in September, 1991, because holes were not drilled and fastened properly. Douglas held up delivery of Production Aircraft for nearly a month while technicians located the leaks. Jim Berry, then Douglas vice-president and general manager of the C-17 program, said the problems stemmed primarily from a lack of production discipline and unscheduled work. The failed wing-strength test and persistent fuel leaks around the wing cost McDonnell Douglas more than $1 billion, and modifications added an additional 700 pounds in aircraft weight (Smith, 1993).

Summary of the DoD Experience

DoD did not look at its investment in the C-17 from a technically strategic view, nor did it appreciate the challenge of C-17 STOL technology. When DoD changed the mission of the tactical STOL to a strategic STOL, both McDonnell Douglas and the Department of Defense underestimated the scope and cost of the effort necessary to reduce the aircrew size to three persons and fly 2,400 NM with a 172,200-pound payload. As Fogleman said, DoD "...allowed the plane to be over spec'd unnecessarily....We didn't need a plane to carry a 172,200-pound payload then and we don't need a plane to carry 160,000 pounds now" (Fogleman, 1995). In both cases (reducing aircrew size and requiring STOL) McDonnell Douglas had to increase its use of computerized flight controls in order to maximize performance. In all cases lack of experience with software caused schedule delays and increased cost. In addition a math error caused problems that prevented the C-17 wing from passing the stress test at 150 percent. If McDonnell Douglas had a CAD/CAM system like CATIA, it might have detected and prevented both the stress problems and the fuel leak problems.

Contrasting the DoD and Boeing Approaches

Boeing's focus during the design and acquisition process was on cost, schedule, performance, and market competition. DoD's focus during the design and acquisition process was on performance. Boeing looked at the technology included in its airplane more realistically and did not try to include more than the market would buy. DoD, on the other hand, gold-plated requirements by providing more capacity than the customer needed, and underestimated the STOL technology and cost needed to carry a 172,200-pound payload. Boeing used the CATIA computer program to help revolutionize its design and manufacturing plant so that parts would fit right, and built an entirely new plant to integrate and test its new avionics package. Boeing's investment in infrastructure helped overcome its many

computer and avionics problems. DoD's contractor, McDonnell Douglas, designed the C-17 on paper. McDonnell Douglas did not use a computer program that could have identified and helped eliminate both the wing stress and the fuel leak problems, and it did not adequately plan integration of the C-17 avionics package.

When Boeing underestimated the time and cost to overcome technical problems in the 777 fly-by-wire and CATIA, it determined what it needed to do to correct the problems. Boeing decided to meet its delivery date to United, and commit additional money and resources to solve the technical problems. DoD, on the other hand, upon learning that McDonnell Douglas could not meet its first scheduled flight because of technical problems that included software and STOL design, took money away from the program and stretched it out three years.

Jacques Gansler in his book, *Affording Defense*, explains how DoD's preoccupation with technology is self defeating:

> ...the unreasonably long acquisition cycle (10-15 years)...leads to unnecessary development costs, to increased "gold plating," and to the fielding of obsolete technology (Gansler, 1989).

What happens is that DoD takes so long to overcome technology problems that by the time a weapon is complete, the technology is outdated. In the case of the C-17, that's true. It is the most versatile up-to-date cargo plane the U.S. currently has, but DoD couldn't produce the C-17 until the technology problems of design, fly-by-wire, embedded computer systems, and wing stress were solved. As a result, Boeing completed the 777 at about the same time even though it was conceived several years after the C-17. The 777 uses the same level of technology or, as with flat-panel displays, computer-design, increased propulsion, and manufacturing processes, it uses more advanced technology.

Jacques Gansler describes the dilemma between the Defense and commercial approach to technology in his illustration of a college student working in the commercial world versus one who works for defense.

> A typical American engineering student (graduate or undergraduate) is taught how to design the "best system." Using computers, sophisticated mathematics, and all their engineering skills, these students set out to design systems that will achieve the maximum performance. If they enter the commercial world, they are taught that their designs should be modified to reduce the likely costs of production and operation. However, if they enter the defense world, they continue to use the design practices they learned in school, and cost-cutting becomes an exercise for the manufacturer (Gansler, 1989).

If DoD continues its past preoccupation with technology, it will fall behind. In the past commercial development programs leveraged the technology developed by the military; this was certainly true for the 777 fly-by-wire. However, the military is now learning from commercial developers. The F-22 and other acquisition programs are using the integrated product teams that Boeing developed in its design-build approach. The F-22, the B-2, and the V-22 Osprey are all benefitting from CATIA and the strides Boeing made in composite manufacturing. However, the programs are not benefitting from Boeing's design-to-cost approach.

Conclusions

Did the difference in approaches to technology contribute to the length of time it took to develop the DoD C-17 compared to the Boeing 777? One would have to say yes. The most telling difference was how Boeing and DoD reacted to technical problems that threatened to impact delivery dates. Boeing added more resources to overcome technical problems whereas DoD took resources away and moved the delivery date out three years. As long as DoD overestimates the maturity of technology it wants to use, asks for more technology than it needs, does not commit resources to overcome technology problems in a timely manner, and does not require cost, schedule, and technology trade-offs during evolution of the design, it will take longer to develop weapon systems.

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COOPERATIVE ACQUISITION PROJECTS IN THE PACIFIC RIM

Richard Kwatnoski

This is the third of three related research studies of cooperative acquisition projects conducted by DSMC. It describes the current reality of cooperative projects in the Pacific Rim, identifies barriers to and facilitators of cooperation, and examines similarities and differences between PACRIM and NATO-Europe projects.

In 1992 the Defense Systems Management College (DSMC) began a study of international cooperative defense acquisition projects between the United States and countries in the Pacific Rim (PACRIM). This was the third of three related research studies of cooperative acquisition projects conducted during the past ten years. The first and second were studies of U.S. and NATO-European projects (Farr, 1985; 1992). Responding to increasing student demand for information on PACRIM projects, DSMC took the lead for the third research study.

The research objectives were as follows:

- Describe the current reality of cooperative projects in the Pacific Rim.
- Determine the prescription for success by identifying barriers to and facilitators of cooperation.
- Examine similarities and differences between PACRIM and NATO-Europe Projects.

The PACRIM study progressed in four phases employing tailored questionnaires and methodology developed during the two previous studies. The four phases are shown in Table 1.

Phase I was conducted to identify the PACRIM countries and projects of interest. The scope of the study was then narrowed to Australia, Japan, and South Korea, as it is with these nations alone that the Department of Defense (DoD) has legal authority to enter into cooperative acquisitions. Cooperative acquisitions must be jointly managed and equitably (or equally) funded by the participating nations. They must also include an international Memorandum of Understanding or Agreement (MOU or MOA) setting forth the terms and conditions of the project. International

Table 1. Study Phases and Participating Organizations

STUDY PHASES	PARTICIPATING ORGANIZATIONS
I. Establish terms of reference notes on cooperation	Office of Secretary of Defense, Defense and Security Assistance Agency, and Service Staffs
II. Notes on cooperation	Allies - Embassies
III. International Acquisition Topics	U.S. Project Offices
IV. International Acquisition Topics	Allies Project Offices Topics and U.S. In-Country Personnel

projects with other PACRIM nations must use Foreign Military Sales (FMS) procedures. The projects identified for study are shown in Table 2.

Phases I and II of the study were combined to produce general and country-specific notes on cooperation. These are covered in the next section.

Phase III conducted during 1993 and Phase IV conducted during 1994 focused specifically on the PACRIM projects. Interviews were conducted with both U.S. and allied in-country representatives of each of the project offices. Because questionnaires provided to U.S. and allied project offices in PACRIM were identical, and because the questionnaires were similar to those of previous U.S. and NATO-Europe project studies, comparisons of U.S. and allied views on cooperative acquisition is possible, as are comparisons between PACRIM and NATO projects. The allied project offices visited are shown at Table 3.

One of the great difficulties in a study of the prescription for project success is in determining the definition of success. Early on in the study a simple definition was developed. Success was defined as (a) completing a formal MOU, (b) obtaining funding provided from the participating nations, (c) initiating the project, and (d) encountering no withdrawal or termination due to unresolved problems. All the projects studied met this definition. Defining success in this way, as well as the nature of the projects available for study, led to a focus on the very preliminary stages of the acquisition process.

Notes On Cooperation

General

First and foremost, it must be kept in

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mind that there is no equivalent to NATO in the Pacific Rim. This means that there is none of the vast NATO-type infrastructure in place to support cooperative activities with Pacific Rim nations. Therefore, with few exceptions, our cooperative acquisition projects with Australia, Japan and South Korea are conducted bilaterally, and will remain so for the foreseeable future. The U.S. enjoys favorable defense trade balances with the three nations, and is pressured therefore to give generous terms in cooperation. Furthermore, one should not be fooled into stereotypical thinking. Each nation is different: Japan is not like Korea and Australia is different in many ways from the U.S. Between each nation there can be enormous cultural differences, management styles, and motivations for cooperative acquisition. One should also be aware of "European Strings" that may tie America's hands in the Pacific Rim because of prior commitments made in European projects. Interestingly, there was a perception among the U.S. staff personnel interviewed that our system was the most problematic when it comes to cooperative acquisition. This was especially pronounced in our legal system (e.g., treatment of intellectual property rights) and acquisition system (e.g., competition policies).

Australia

Australia is geographically a Pacific Rim nation but is heavily populated with transplanted Europeans. For Americans, Australia is culturally the easiest nation to work with in the Pacific Rim, if not in the world. Further smoothing relations, Australia is not viewed as a competitor to the United States, whether economically or in the defense export market. The Australian defense budget is smaller than that of the U.S. but proportionately larger in its expenditure for research. Not surprisingly, Australia seeks more cooperative projects with the U.S. to develop outlets for its research technology and to attain rational production quantities. The Australian rationale for cooperation is to access foreign technology, promote its own technology, realize econo-

Table 2. The Projects Studied

PROJECT	MILITARY DEPARTMENT OR DEFENSE AGENCY	ALLIED NATION
Next Generation Support Fighter (aka FS-X)	Air Force	Japan
Ducted Rocket Engine	Army	Japan
Coastal Harbor Defense	Navy	South Korea
Ammunition Storage Technology	Army	South Korea
Digital Chart of the WorldAgency	Defense Mapping	Australia
Radar Activities	Air Force/Navy	Australia
MK-53 Off-Board Active Decoy (aka Nulka)	Navy	Australia

Table 3. Project Organizations Visited

PROJECT	U.S. ORGANIZATION	ALLIED ORGANIZATION
Coastal Harbor Def. Ammo Storage Tech	NRL, Washington, D.C. TCES, Savanna, IL Support: JUSMAG-K	ADD, Chinhae ADD, Taejon
FS-X Ducted Rocket Engine	F-16 SPO, WPAFB, OH MICOM, Huntsville, AL Support: MDAO	TRDI, Tokyo TRDI, Tokyo
Radar Activities Nulka Digital Chart of the World	ESC, Hanscom AFB, MA TAD PEO, Crystal City, VA DMA, Fairfax, VA Support: ODC	JORN PMO, Canberra Nulka PO, Canberra Dir. of Survey - Army, Canberra

mies of scale, promote interoperability, and encourage industrial participation that will result in a "residual" capability retained in Australia after project completion.

Australia explores cooperative project opportunities in a variety of ways. These include the structural process (attaches, exchange officers, etc.), multilateral forums (ABCA, TTCP, 5 Nations, etc.), senior national representative meetings, and project teams specially formed to examine the pros and cons of the cooperative project.

Australia cooperates with many nations besides the U.S. With New Zealand, efforts have been made to attain rational production quantities for many types of defense material; so, too, with the United Kingdom, primarily on naval projects. Australia also desires to strengthen ties with its other Pacific neighbors. There have been successes in joint exercises, logistics, and sales, but no armaments cooperation as of this writing.

Australians cite several difficulties in cooperating with the U.S. The release of technical information is often at issue. The complaint of being "ambushed by the many," a reference to the large number of players in the U.S. approval process, is heard. American commitment at the working level is acknowledged, but seems lacking at the staff level and within the financial community. The "NIS syndrome" was mentioned: This is an Australian perception that if the defense article is "not in service" in Australia, then the U.S. is not interested. Also mentioned as difficulties were the great distance between the two nations, the 12-hour time difference, differing national priorities, and the size mismatch on production rates and quantities.

From the U.S. perspective, a long history of military cooperation, a lack of economic competition, and a common motivation for armaments cooperation pose few problems. Access to software source codes remains an issue, however, though historically the U.S. has not released these to any nation. Australia is a natural candidate for expanded cooperation.

Japan

An understanding of the potential for cooperative acquisition projects with Japan

must begin with a review and understanding of Japanese policies regarding their defense relationship with the United States. These policies include the Japanese "No War" Constitution (post World War II), the Mutual Defense Assistance Agreement (1954), the Japan-U.S. Security Treaty (1960), the Three Principles on Arms Export (1967), Government Policy Guidelines on Arms Export (1976) and the Agreement on Technology Exchange (1983). Basically these policies preclude Japan from exporting armaments, and from sharing defense technology with any nation other than the U.S.

There is an anti-military sentiment within Japan, and to further confound cooperation there is an anti-Japanese military sentiment in neighboring Far Eastern nations. There are also deep cultural differences between us, and the economic difficulties between the U.S. and Japan are reported daily in the American press. In summary, many external factors hinder the formation of cooperative acquisition projects with Japan.

The Japanese Defense Agency (JDA) conducts little in-house research, yet cooperation in research remains feasible because, unlike DoD, the JDA does not purchase unlimited rights to intellectual property associated with defense articles. However, the Japanese do favor classified agreements, a preference that further complicates cooperation.

The Japanese examine the possibility of cooperation based upon four "merits" that ask whether it is likely to:

1. Prove appropriate for the Japanese environment.

2. Allow for improvements after procurement using Japanese technology.

3. Insure that long term logistics support is available.

4. Enhance the growth of the Japan's defense industrial base and technology.

While Japan's indigenous research and development is of paramount importance, the Japanese view some cooperation with the U.S. as necessary. Although Japan responds to U.S. initiatives in cooperation, it seldom if ever initiates cooperative acquisition projects itself.

Issues that may arise in cooperation with Japan include technology transfer and control (especially software), differing capabilities of the U.S. and Japan defense industrial bases, joint ownership of intellectual property rights, and technology flowback. The last has been a persistent issue involving disagreement about the meaning of *native Japanese technology*, which Japan is required to provide, or flow back, to the U.S.

Real cooperation is only possible with the United States. Japan favors the Data Exchange Agreements and the Systems & Technology Forum for identifying cooperative opportunities. The future of cooperative acquisition projects will be on a case-by-case basis, with clear and complementary motivations often lacking.

South Korea

Recent moves toward democracy in South Korea have reduced the influence of the military, but the nation's defense industry still responds to government direction. High technology transfers to South Korea are considered in the context of a potential conflict (or, alternately, reunification) with North Korea. South Korea does little pure research, and therefore favors co-production. All cooperative projects must have a ready application.

There are cultural differences between Americans and Koreans: Koreans may seem overly attentive to detail at times and to put nearly everything in writing. Yet the cooperation of one's Korean counterparts

can also depend on personal rapport: Anticipate changes to a project when changes in key people occur. Not surprisingly, Koreans place emphasis on social activities designed to build personal rapport among business acquaintances. Other helpful hints for Americans include pre-planning to provide administrative support, including Korean-English translation, and preparing oneself to truely adhere to schedules.

South Korean officials view cooperative projects with the U.S. as easy to start but difficult to continue. They also view the U.S. as reluctant to make cooperative projects with South Korea work, and speak of "turning our eyes," a euphemism for a shift from Korea's commitment to defense cooperation with America to cooperation with other nations, primarily France and Germany. However, Korea continues to seek cooperation with the U.S.

The issues that typically arise in U.S.-South Korean cooperative projects include technology transfer and control, third party sales, intellectual property rights, total project cost and Korean cost share, and the transfer of research work to a defined project. The Koreans favor Data Exchange Agreements and the Engineer Scientist Exchange Program for identifying cooperative projects.

International Acquisition Topics

The study yielded information on the following acquisition related topics, each of which is explored in detail in this section.

Project Profiles

All the projects in the PACRIM study were research and development projects, at least half of which also included significant test and evaluation. These were efforts of about $10-$15 million, with half of that having procurement potential. These were primarily technology demonstration or insertion projects or, alternatively, technical data gathering projects. There were two exceptions: The Japanese Next Generation Support Fighter (FS-X) Project is a major acquisition program for Japan, although the U.S. effort consists primarily of monitoring the flow back of technology. The other exception is the U.S.-Australian Nulka project (or the MK-53 Off-Board Active Decoy, as it is now called). The intent is for this project to go through development and into production. Nearly all the projects are of moderate to high technical risk, as might be expected in early R&D. Commercial spin-off was viewed as a possibility in half the projects.

Project Office Profiles

Unlike NATO, PACRIM nations frequently utilize alterntives to fully integrated international program offices with oversight and guidance provided by an international steering group. The favored approach in over half the projects was a dual project office structure, where funds and technical effort were managed in each nation, with technology and results shared regularly during the life of the project. The lead nation approach was the next most favored, observed in nearly a third of the projects. There were no integrated international project management offices in any of the PACRIM projects. This could be attributed to any or all of the following: a lack of project maturity, the bilateral nature of the projects, and the stipulation attached to U.S. Cooperative Research and Development Funds (a.k.a. Nunn Amendment funds) that the U.S. portion be spent in the U.S. While there were no integrated international project offices, three approaches were employed to facilitate the international nature of the projects:

1. Liaison officer: This was used with the

Japanese FS-X project and the Australian Nulka project, the latter having an Australian liaison officer in the U.S. project office, with no reciprocity.

2. In-Country support: This method was favored in the Korean projects, with the support provided by the Joint U.S. Military Advisory Group.

3. Embassy Contact: This was the approach clearly favored with the Australian projects, where the embassy in Washington plays an active role.

The use of an international steering group, so highly favored in NATO projects, was used in only half the PACRIM projects. While those who utilized a steering group believed this structure beneficial, the others believed that a steering group was not necessary.

Project Initiation

The study addressed the mechanism, rationale, barriers, and facilitators for program initiation, as well as an assessment of international partner potential. Regarding the mechanism for program initiation, the surprising finding was that there was no common approach or forum for this. As Table 4 illustrates, each project began differently. While only one project initiation was attributable to a data exchange agreement, half the project offices mentioned that an existing agreement greatly facilitated the project.

Program Rationale

Examination of the motivation of U.S. project personnel to enter into international acquisition projects could help to identify future candidates for cooperation. Not surprisingly, over half stated that a common threat or need was the motivation. While this is the expected answer, almost half had other motivations. One reason was to access cooperative R&D funds. Other rationales were political motivation, technical benefit, and standardization goals.

Table 4. Program Initiation Mechanisms: All Are Different

- Defense Security Assistance Agency Initiative
- Bilateral Forum
- Office of Secretary of Defense Directed
  (To solve technical problem)
- Data Exchange Agreement
- Senior Level Bilateral Meeting
- Multilateral Forum
  - 5 Nations Meeting
  - ABCA Forum

Barriers to Cooperation

The U.S. view on barriers was very clear. Nearly all the American project officers identified the cumbersome MOU-MOA process as a barrier to cooperation. Their specific problems or complaints took many forms: the difficulty of obtaining staff coordination of the MOU-MOA; the length of time associated with the process (almost always significantly underestimated); the difficulty associated in one case with a change in legal advisors, reopening an MOU to negotiation; and the use of a program MOU (for the entire R&D and production cycle) rather than an MOU for a single phase of acquisition. And one other barrier surfaced: In half the projects, objections from other agencies or departments were identified as a problem. Mentioned in order of frequency were the Defense Technology Security Administration (DTSA),

the Departments of Commerce and State, and finally other military departments.

The allied view identified cumbersome U.S. procedures as the major barrier to cooperation. While the MOU process was mentioned most frequently, the allies also encountered difficulties with American testing and technology release procedures. Surprisingly, almost half the PACRIM allies' project offices cited out of phase national budget processes as being a barrier, while U.S. project offices never mentioned this as a barrier. U.S. project personnel need to be more sensitive to the differing budget cycles of allied nations.

Facilitators of Cooperation

Not surprisingly, over half of the U.S. project office representatives focused on the project requirements as facilitators of cooperation. The term *requirements* could refer to a technical objective, operational requirement, specification, or number of production units, and was not defined. Nevertheless, clarity, stability and mutual understanding of project requirements were considered to be of paramount importance. Also cited with nearly the same frequency was the commitment and support at a high level received by the cooperative project. For example, it was thought that the Ducted Rocket Engine would have never moved forward without Office of the Secretary of Defense support. Other facilitators cited were a perception of equitability of benefits, having a liaison in the partner's country, and shared program objectives. Only one U.S. project office staff stated that they had no significant problems during the MOU process. They gave as a reason that they had engaged in two years of preplanning and technical discussion with their allied counterparts under an existing Data Exchange Annex (DEA) prior to entering the formal international negotiation process.

A comparison between U.S. and allied views on what facilitates cooperation was most revealing. One of the two most common responses from allied project offices was having a common goal. Though similar to the U.S. view, the allies' perception seemed gauged to broader program goals, rather than the specifics of technical or operational requirements. Another frequent response was *trust*. This was a surprise in that it was the most frequent allied answer, yet was never mentioned by U.S. project office representatives. This same phenomenon occurred during studies of European projects (Farr, 1985; 1992), where the need for *commitment* was mentioned often, but exclusively by the Europeans. This suggests a profound cultural difference between the U.S. acquisition personnel and their allied counterparts regarding the value placed upon trust and commitment necessary in an international project. Two additional answers were mentioned: complementary skills and technology and prior meetings, neither appearing on the U.S. list. It is essential to understand these differences to attain success.

Potential Partners

Here again the differences between the U.S. and allied views are revealing. When asked about the desirable characteristics of a potential international partner, U.S. project office personnel found consensus on only one answer: mutual interest. No other answer appeared more than once, but the list also included: available funds, a win-win attitude, high level advocacy, technical capability, commitment, a signed royalty agreement, or a perception of urgency. One of the two most common allied responses was a common goal or need, similar to the most prevalent U.S. response. However, it came from less than a third of the project offices, and was mentioned with the same frequency as complementary skills and technology. The latter was never mentioned by U.S. representatives. Other responses re-

ferred to the existence of a political alliance, past experience, proven performance and reliability, interoperability of defense equipment, and an equal-partner mentality.

International Concerns

An assessment of five aspects of international projects and their impact upon Pacific Rim projects was conducted. Both the U.S. and allied views were considered.

Geographic Separation

Not surprisingly the U.S. project offices viewed geographic separation as a problem with all three of the nations considered. What was unexpected was that our Australian, Japanese and Korean counterparts minimized the importance of this aspect. They often cited modern technology easing this problem. First hand experience proves the necessity of a 24-hour fax machine for efficient communication.

Cultural Differences

The U.S. project office staffs cited cultural differences as a significant problem when working with their Japanese and Korean counterparts, but of minimal concern in working with the Australians. The Australians agreed with the U.S. view. The Japanese saw cultural differences as a problem, though not a significant one, and the Koreans said that cultural differences between themselves and the Americans were of minimal impact in international projects.

Language Differences

Not at all surprising was the agreement between the Americans and Australians that language differences have a minimal impact on their cooperation. The Americans agreed with their Japanese counterparts that language was not a significant problem. Americans reported that most of the Japanese they dealt with in cooperative defense acquisition projects had been educated in the U.S. and could read English very well and speak it with some difficulty. Regarding their Korean counterparts, the Americans saw language as a significant barrier to cooperation, while the Koreans saw it as a lesser problem. This was expressed by one Korean project officer: "Language differences are not a great problem because we speak the common language of science." Many South Korean scientists also obtain part of their education in the U.S.

Technical Capability

The fourth international aspect examined was whether differences in technical capability between the U.S. and partner nations caused significant problems. There was a rough consensus between the U.S. and allied project offices that this was a problem, but not a significant one. Koreans did not believe this to be a problem at all. The U.S. project office staffs believed that this was not a problem with Japan at the technology level, but that the integration of technologies, components and subsystems into a major defense system could be a concern.

Managerial Differences

The fifth and final international aspect examined was managerial differences. There was clear consensus between U.S. and allied project offices that this was a problem area. Not a single nation indicated that this was of minimal impact. There were varying degrees of concern by country. The U.S. and Japanese project office staffs agreed that this was a significant problem area. The Americans believed this also was a significant problem for the Koreans, but the Koreans did not believe it to be significant. The U.S. and Australian project office staffs believed this to be a problem area

between them, though not as significant as that each had experienced with Japan. Unfortunately, the study did not get into the specifics of the managerial differences that caused problems, which will remain an area worthy of additional research.

In summary, managerial differences appear to be the greatest concern in international cooperative acquisition projects with PACRIM nations (especially with Japan). Differing technical capabilities also pose some concerns. Geographic separation, cultural differences, and language differences seem to be of lesser impact. In general, the U.S. project personnel viewed international concerns as posing more significant barriers than their allied counterparts. Most of our allies are accustomed to obtaining defense equipment from outside their own country, while the U.S. makes most of its purchases at home.

Requirements and Goals

An assessment of the project requirements and goals process was conducted. This covered technical requirements, operational requirements, or general project goals (or all three) agreed upon by the nations involved. Although this was the most troublesome aspect of the NATO-Europe projects, in the PACRIM projects the requirements and goals were jointly developed and specified at the onset of the project, user needs were apparent, and there were no significant problems. Perhaps lessons have been learned from the NATO-Europe projects, or perhaps it is just too early in the acquisition cycle to detect problems with the requirements and goals. It is also true that political pressure altered the goals in half of the programs, but only before the MOU was signed. After the exposure to the formal MOU process, requirements and goals stabilized. This points to a strong need for the acquisition manager to minimize the exposure time of the project to the formal MOU-MOA process.

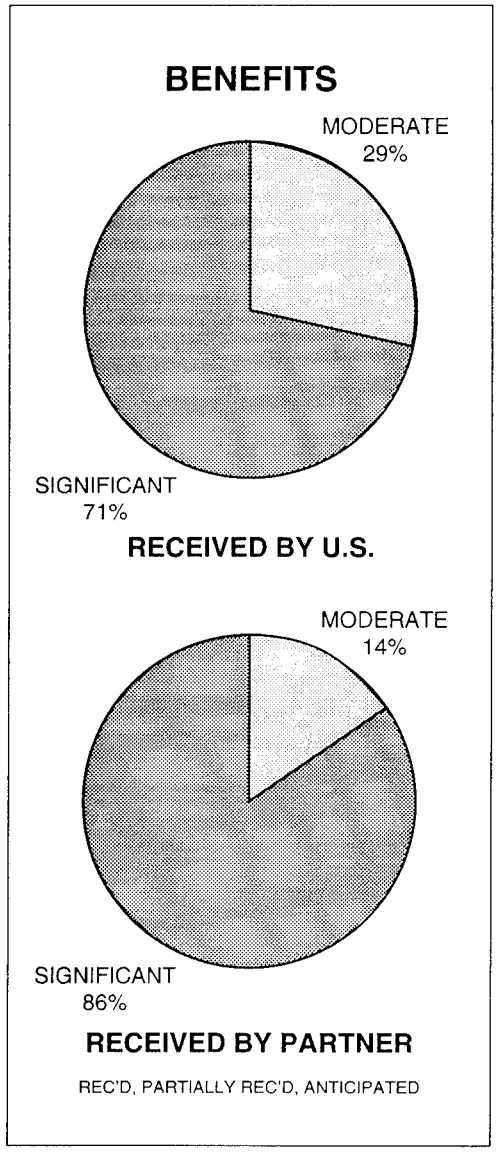

Figure 1. Equitability

Equitability

Because there is a statutory requirement that international cooperative programs be *equitable*, U.S. project office staffs were surveyed as to their opinions on the benefits received by the U.S., as well as their perceptions of the benefits received by allied partners in the project. As Figure 1. shows,

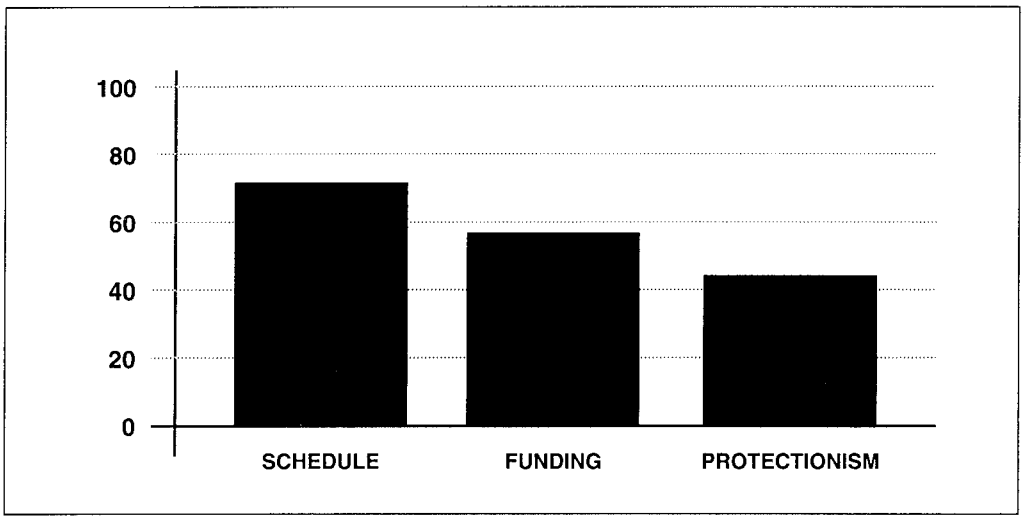

Figure 2. Acquisition Concerns

the benefits were perceived to be moderate to significant. Clearly the U.S. project office staffs perceived equitable benefits from the cooperation. Partner exploitation did not appear to be a problem to the Americans as about three quarters of U.S. project officers believed that neither partner was exploited, and the remainder said it was too early to tell.

Acquisition Concerns

A general assessment was conducted of the key areas of acquisition uncertainty associated with these international projects. This is shown in Figure 2. Especially pronounced were the high percentage of projects experiencing impacts on cost and schedule. The areas of uncertainty are clearly identifiable and appear significantly frequent. Regrettably, there is no comparable set of data for domestic acquisition projects that might show similar problems.

International Training

An assessment of the international training needs of the U.S. project offices was conducted. Fully two thirds said that it was needed and would have helped the early stages of the project. The training topics most frequently mentioned were international agreements and intellectual property rights. Also mentioned were third party transfers beyond the nation participating in the project, cultural aspects, foreign policy, and Foreign Military Sales (FMS).

General Comparisons

Table 5 lists some general comparisons between the NATO-Europe projects from previous studies and the Pacific Rim projects examined under this study. The key point is that the cooperative projects from the two regions are considerably different. I conclude that anyone well versed in cooperative projects with European nations may need to relearn the business when working with the Pacific Rim nations.

Final Thoughts

PACRIM Cooperation Is Different

True cooperation in acquisition projects is in its infancy in the Pacific Rim. It is

Table 5. General Comparisons

NATO-EUROPE	PACIFIC RIM
Many Projects	Few Projects
Growth in 70's/80's; Recent Declines	Recently Emerging
Larger RDT&E $	Smaller RDT&E $
Cooperative Development and Production	Cooperative R&D
Expect & Desire Production	Production Intent Unknown or N/A
Many Multilateral	Almost Exclusively Bilateral
Intra-European Cooperation Common	No Intra-PACRIM Projects
Mixed Political Support	Less Political Support
Significant Cultural Differences	Enormous Cultural Differences
Complex Management Structures	Lean Management Structures
Traditional Program Manager	Technical Project Coordinator
International Program Management Offices	Key Individual In-Country or Coordination through Embassy
Collocation	No Collocation
More Use of Steering Committee	Less Use of Steering Committee
Commitment Important	Trust Important

twenty years behind our efforts with the NATO-Europe nations. Experience with NATO projects may be of little value in the Pacific Rim. Has the U.S. defense acquisition community learned the prescription for success in the Pacific Rim? On the one hand we seem less prone to canceling international projects, yet on the other hand the projects have degraded to rather simple, early R&D efforts.

Expectations for cooperative projects with PACRIM nations should be realistic. The key to future success will be to demonstrate commitment and build trust. I also believe that the bilateral approach now pursued by the U.S. may not provide sufficient synergy for continued cooperation. Is there no forum in which all the nations of the Pacific Rim could participate to increase cooperation in defense acquisition?

Anticipate Problems

There are key problem areas that the acquisition manager should anticipate when entering into a cooperative project in the Pacific Rim. These are the known unknowns; there are no clear solutions, but certain strategies can mitigate the impacts. First, anticipate significant problems during the formal international agreement (MOU-MOA) process. Anticipate this to result in changes to project objectives, in schedule delays and in funding problems. These agreements are normally approved at the highest level and seldom approved below the service secretary level. This visibility inevitably attracts many organizations with many conflicting agendas to the process. The acquisition manager's strategy is to minimize the time an MOU-MOA is exposed to the process. Some of these problems may be reduced with the recent streamlining policy promulgated by the Deputy Secretary of Defense (1994).

It is imperative to resolve as many issues as possible before starting to negotiate formally. Many technical points can be resolved under a DEA. The main restriction is that a draft MOU-MOA, or similar document cannot be tabled or even discussed (DoD Directive 5530.3, 1987). I advise all acquisition managers even contemplating an international cooperative project to get a DEA in place as quickly as possible and use it as a vehicle to resolve as many issues as possible prior to formal negotiation. In other words, minimize your exposure time to the highly political MOU-MOA process.

Second and nearly as troublesome, anticipate objections to your international project. These objections can come from virtually anywhere to include other military departments, other DoD agencies, and other government agencies (including State, Commerce, and possibly Treasury), as well as the Congress.

The international acquisition manager is a consensus builder dealing with a plethora of nay sayers far exceeding that found in domestic programs. Begin coordination early to build consensus. Advocacy is essential for your international project within the Office of the Secretary of Defense and the services' international programs staffs. With this it will be difficult; without this impossible.

A List of Do's

While international cooperative acquisition projects are fraught with pitfalls, they can be successful. In fact all the projects studied were considered successful, and most or all will successfully meet their original goals. Based upon this study, and the years of research preceding it, I proffer the following list of do's.

1. **Concentrate on *mutual* benefits and needs.** Always try to assess your allies' needs, and arrange for equitable benefits. While the equitability of the project from a strictly U.S. view will be determined by many sources, no one in the U.S. is responsible for looking at our

partner's needs. The acquisition manager is normally the one who must live with the agreement and execute the international project. He or she should strive for a win-win situation, if additional international activities are envisioned.

2. **Take fresh, creative approaches.** International projects add a layer of complexity to an already difficult acquisition process that does not readily accommodate international projects. Recent initiatives and innovations may smooth out some of the difficulties. Some examples are the recent streamlining of the international agreements process, the use of special types of agreements (such as the umbrella and chapeau agreements) a computer program to assist agreements negotiators, and the use of DEAs to resolve early issues. Surely, more creativity will be needed during the project execution phases, beyond just the approval of the MOU-MOA.

3. **Stabilize and clarify requirements.** While requirements did not appear as problematic as in the past studies of a NATO-European projects, it is too soon to tell whether this will become the show-stopper as some of the projects progress through the acquisition cycle. Nevertheless, even at these early stages, stable, clear requirements were well recognized as the primary facilitator of a cooperative project, especially by the U.S. project personnel.

4. **Prepare and coordinate up front and early.** Consensus and advocacy are essential elements in all acquisition projects, but the level and span for international projects is much greater and extends beyond just the DoD.

5. **Minimize exposure time to the MOU-MOA process.** Exposure to the political levels during the formal negotiation process is likely to result in changes to project goals, as well as significant impacts on schedules and funding. The acquisition manager must exert every effort to shorten exposure time by building consensus and resolving issues before the process formally begins.

6. **Learn to be trustworthy.** This was the greatest cultural divide between Americans and our allies. Trust is of great importance to our Pacific Rim allies, but never mentioned by Americans as an essential element of cooperative acquisition projects. This seems to be further exhibited in the U.S. approach of addressing every possible contingency in the extraordinarily lengthy, detailed project agreements, for which we have resorted to computer programs to develop.

7. **Train and educate acquisition professionals before they start the international dialogue.** It was clear during the study that none of the U.S. project personnel had taken advantage of available international training. This deficiency has been noticed and documented before (Kwatnoski, 1992). International projects require PET: preparation, experience and training. The reality is that U.S. personnel often pull the proverbial "PET" rabbit out of the hat when it comes to international projects. On October 1, 1994, all of DSMC's three international acquisition courses were officially identified as "assignment-specific Defense Acquisition University courses" by the Under Secretary of Defense for Acquisition and Technology. It remains to be seen how this will be implemented within the acquisition workforce. The services have already expressed a desire to send nearly 10,000 acquisition workforce personnel to our international

courses. I believe this will bring about a grass roots revolution in our ability to engage in international projects. The ultimate solution will be to have certified international acquisition corps personnel managing all of DoD's international projects and related activities.

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List of Acronyms

AABCA – American-British-Canadian-Australia (Refers the standardization agreement and organization comprised of these countries, with New Zealand as an observer.)

ADD – Agency for Defense Development (Refers to the South Korean Defense Agency responsible for development of defense equipment.)

AFB – Air Force Base

DAU – Defense Acquisition University

DEA – Data Exchange Annex (Refers to an annex on a particular technical area to a Master Data Exchange Agreement between the U.S. and another nation. Allows for the international exchange of scientific and technical information among scientists and engineers.)

DMA – Defense Mapping Agency

ESC – Electronic Systems Command, USAF, Hanscom Field, MA.

FS-X – Fighter Support-Experimental (Original designation of the next-generation Japanese tactical fighter. Now designated as the Next Generation Support Fighter.)

JDA – Japanese Defense Agency (Equivalent to the U.S. Department of Defense, but is not a cabinet level department.)

JORN – Jindalee Operational Radar Network (Refers to a large Australian project that included the U.S.-Australian Radar Activities, or Over-the-Horizon Radar, Project.

JUSMAG-K – Joint U.S. Military Advisory Group - Korea (See also MDAO and ODC as similar organizations in Japan and Australia.)

MDAO – Mutual Defense Assistance Office (See also ODC and JUSMAG-K as similar organizations in Australia and South Korea.)

MICOM – Missile Command, U.S. Army, Huntsville, AL.

NRL – Naval Research Laboratory, Washington, D.C.

ODC – Office of Defense Cooperation (See also MDAO and JUSMAG-K as similar organization in Japan and South Korea.)

PEO – Program Executive Officer

PM – Project Manager

PMO – Project Management Office

PO – Project Office or Officer

SPO – Systems Project Office

S&TF – Systems and Technology Forum (A bilateral U.S.-Japan forum for exchanging technical information and identifying potential cooperative projects.)

TAD – Theater Air Defense

TCES – Technical Center for Explosive Safety, U.S. Army, Savanna, IL.

TRDI – Technical Research & Development Institute, Tokyo, Japan (The research and development part of the Japanese Defense Agency.)

TTCP – The Technical Cooperation Program created to acquaint participating countries—see ABCA—with military R&D programs to promote international cooperation.)

WHAT EVERY GOVERNMENT EMPLOYEE SHOULD KNOW ABOUT POST-FEDERAL EMPLOYMENT RESTRICTIONS

Timothy Dakin

This paper discusses the three principal, yet conflicting, laws concerning the post-federal employment restrictions on Government employees at present, especially for those employees involved in the acquisition process.

Periodically, Congress has enacted legislation imposing various restrictions on the nature of work in which former federal employees may engage. This legislation and its implementing regulations has created a patchwork quilt of inconsistent requirements and uneven enforcement. Nor has the recent Federal Acquisition Streamlining Act (FASA) succeeded in bringing any real order or reason to the law. This paper reviews these laws as they presently exist and attempts to point out where reform is appropriate.

Three statutes, each applying to a different universe of former federal employees, will be discussed in detail. The most encompassing, applying to all former federal officers and employees, regardless of grade, is 18 United States Code §208, which provides for criminal sanctions against an offender. The second, 10 United States Code §2397b, often referred to as the Revolving Door Statute, applies only to certain former Department of Defense (DoD) officers and employees, and then only in limited circumstances. It provides for administrative sanctions against the former employee and the company employing that person's services after leaving the government. The third statute, 41 United States Code §423, the Procurement Integrity Act, applies only to former federal employees who performed a procurement function, as defined in the law and its implementing regulation. However, this group could include persons not covered by either of the other two statutes. The Act contains civil, contractual, and administrative sanctions against both the former employee and the contractor aiding in the violation of its terms.

There are two other statutes imposing restrictions on retired military officers. FASA repealed one, 37 United States Code §801, the civil selling statute. It denied re-

tired pay to retired *regular* officers engaging in selling supplies or war materials to any DoD agency, the Coast Guard, the National Oceanic and Atmospheric Administration, or the Public Health Service. Forfeiture of pay was limited, however, to the first three years following retirement. The second law, 18 United States Code §281, the criminal selling statute, imposed a two-year ban against any retired officer receiving any compensation for representing another in the sale of anything to the government through the department from which he or she retired. FASA suspended this statute until the end of 1996. Congress seems a trifle uncertain as to what to do with this legislation, having previously suspended it from December 1, 1989, until June 1, 1991. It's important, therefore, for that unique universe of retired officers affected by the law to be mindful that, as the end of the suspension period nears, Congress would breathe new life into it by doing nothing.

18 United States Code §207

This statute applies to all former federal officers and employees, regardless of rank or grade, and regardless of the nature of their former duties. While there are six substantive restrictions in the law, only three are truly relevant to the vast majority of federal employees having some association with the acquisition process. Two of these apply without regard to rank or grade, and the third pertains only to former senior-level employees.[1] The Office of Government Ethics (OGE) has issued regulations implementing the law, which are found in 5 Code of Federal Regulations at Parts 2637 and 2641.

The law in no way restricts for whom a former federal employee may work, but it does limit the nature of what that former federal employee may do on behalf of the new employer. Secondly, it is not limited to persons working as employees, but includes independent contractors as well. Additionally, it does not prohibit the former employee from representing himself in appearances before or communications with the government.

[1] The statute only applies to former officers and employees; it does not apply to former enlisted personnel. The OGE regulation, of course, does not concern itself with the policy issue as to whether the Department of Defense should extend this coverage by regulation to enlisted personnel. However, the DoD supplement to the OGE regulation, DoD Directive 5500.7 (August 30, 1993), also known as the Joint Ethics Regulation (JER), stipulates that certain OGE regulations do apply to enlisted personnel. However, the regulations listed do not include 5 C.F.R. 2637. This is perhaps an oversight on the part of the DoD, because one of the included regulations is 5 C.F.R. 2641, implementing the third restriction in 18 U.S.C. 207, which by its terms only applies to senior officers in the grade of 0-7 and above and employees whose pay is equal to or greater than that for Level V of the Executive Schedule. This creates the interesting situation of certain legal restrictions being applicable to enlisted personnel and senior-level officers and DoD civilian employees, but not to all other officers or DoD civilian employees. Furthermore, it only seems reasonable that DoD, were it to attempt to extend the statutory coverage by regulation to one portion of 18 U.S.C. §207 (implemented by 5 C.F.R. 2641), would attempt to extend it to other portions of the same statute (as implemented by 5 C.F.R. 2637). Not doing so appears to be an oversight.

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The first of the three relevant prohibitions imposes a lifetime bar against a former federal officer or employee acting in a representational capacity, whether formally or informally, in communications with the federal government concerning a particular matter in which the former officer or employee participated personally and substantially while a federal employee. Representational activities would include appearing before or providing documentation to the government in connection with some claim or other proceeding; however, such activities also include correspondence or telephone calls.

The subject of the representation must be a particular matter and the former employee must have participated in this particular matter personally and substantially, rather than peripherally. Again, the key issues involved in determining questionable conduct are whether the ex-employee's prior participation was personal and substantial and involved a particular matter. The statute does not define these terms, but 5 C.F.R. §2637.201 does. It advises that a *particular* matter "typically involves a specific proceeding affecting the legal rights of the parties or an isolatable transaction or related set of transactions between identifiable parties." The regulation further states that rulemaking, legislating and forming general policy, standards or objectives do not entail particular matters. Clearly, a government contract, a specific matter affecting the legal rights of identifiable parties, would be a particular matter within the OGE definition.

The question is frequently posed as to whether a "follow on" contract, or the reprocurement of a defaulted contract, is the same particular matter as the original contract. There is no clear rule to be applied here. OGE advises that relevant questions include whether the same basic facts are involved, if the issues are related, if the same parties are involved, what time period has elapsed, if the same confidential information is involved, and if an important federal interest continues to exist. It uses the example of the government's proposed award of a "follow on" contract to a new entity six years after original award, using new technology, as being a different matter. Unfortunately, this is not a particularly helpful illustration. The more common situation likely to generate concern would be that in which the "follow on" contract involved the same or similar technology, was to be awarded in a period less than six years following original award, or involved the same contracting parties.

In this regard two federal appellate court decisions are instructive. In CACI-Federal v. United States (1983), it was held that a contract for data processing services, though broader in scope, different in concept, and incorporating some services of the former contract, was not the same particular matter as the initial contract, even though characterized by the lower court as being "essentially a follow-on" to the type of service previously provided. Conversely, in United States v. Medico (1986), the modification of a supply contract for M49A3 60 mm artillery shells (simultaneously adding to the original an amount of artillery shells previously awarded to a defaulted contractor) was the same particular matter.

...note that these requirements are conjoined, implying that one's participation could be personal but not substantial...

Regarding personal and substantial participation, note that these requirements are conjoined, implying that one's participation could be personal but not substantial, or vice versa, yet not violate the law. OGE advises that personal participation is direct, though it would include a subordinate's participation directed by the former employee. *Substantial* participation is significant to a par-

ticular matter, or is perceived to be significant. It entails more than simply having official responsibility for a particular matter or mere involvement of an administrative nature. Reviewing a matter strictly for compliance with certain administrative controls or budgetary constraints is not substantial participation. One possible guide here is that the greater the degree of the former employee's discretionary authority concerning the particular matter, the greater the likelihood of substantial involvement.

Recent decisions of the General Services Board of Contract Appeals and the Comptroller General provide some insight into conduct permissible under the law. CEXEX, Inc. v. Department of Energy (1994) involved an agency computer specialist who may have reviewed a requirements analysis and did assist in drafting a statement of work (SOW), gathering budgetary information, and reviewing part of a "Request for Support Services" memorandum forwarding the SOW. He also provided limited assistance in drafting position descriptions for the solicitation package and preparing the initial Agency Procurement Request (APR), in which he was identified as the agency's "technical point of contact" (the APR was later amended, but he had no role in this revision). He also attempted to find two technical evaluators to replace members of the technical evaluation committee. Given all of this, the board found that his participation was not personal and substantial; rather it was limited to providing statistical data. His review efforts were confined to those matters in which, because of his position, he had some expertise. He did not draft or review any of the solicitation, had no role in developing the rating plan, evaluating proposals, or selecting the contractor.

...§207 imposes a two-year bar against former employees acting in a representational capacity...

In *Textron Marine Systems*, B-255580.3, 94-2 CPD ¶63, an alternate contracting officer's technical representative (COTR), participation in drafting a follow-on SOW was determined to be personal but not substantial. He reviewed the training and logistics portions of the original contract, updated it for current requirements, and assessed the number of training courses required. However, the SOW was substantially amended following his having left federal service, his suggestions were relatively minor, and the majority of those suggestions were not incorporated into the final version.

The second prohibition under §207 imposes a two-year bar against former employees acting in a representational capacity in communications with the government concerning a particular matter that was under their official responsibility in the final year of federal employment. This does not require personal and substantial involvement, although the representation must concern the same particular matter. This prohibition is directed at the supervisor of the employee covered by the first prohibition. The statute does not define the term "official responsibility." The implementing regulation, 5 C.F. R. 2637.202(b), interprets the term rather broadly, suggesting the position description and any delegations of authority as starting places in determining one's official responsibility. The regulation does state that all particular matters under consideration within an agency are under the "official responsibility" of the agency head, and each particular matter is under the responsibility of an intermediate (emphasis supplied) supervisor of an employee personally and substantially involved in that matter. The higher one is in the supervisory chain, then the greater the range of his or her "official responsibility," and therefore the greater the restriction on one's subsequent representational activities. However, the regulation carefully excludes those matters for which an agency has only ancillary

responsibility. For example, simply because a contract requires a funding commitment does not place that contract under the official responsibility of the head of the servicing accounting and finance office.

Under either prohibition there must be some official governmental interest in the particular matter. Obviously, the government has an interest in any contract already awarded or that it contemplates awarding. The difficulty is in attempting to determine when its interest has become something more than merely academic. The regulation requires the government's interest to be direct and substantial, but fails to provide any helpful guidance as to what is comprehended by that term.

There is also a general statutory exception for communications made solely to provide scientific or technological information. However, the statute specifically limits this to communications made pursuant to departmental procedures, entailing, inter alia, publication in the Federal Register that the particular former officer or employee may engage in such activities. There will be situations where one in good faith makes a scientific or technological communication without the governmental agency having first complied with the statutorily mandated procedures. However, because of these strict requirements, anyone arguing that the exception should nevertheless apply encounters a considerable burden of persuasion.

§207 contains no provision concerning how the former officer or employee might obtain guidance as to whether certain actions would violate the law, or the legal effect of such guidance. In rather general terms, 5 C.F.R. 2637.201(e) provides that"(D)esignated agency ethics officials should provide advice promptly to former Government employees who make inquiry on any matter arising under these regulations." It merely indicates the agency should provide prompt guidance, not requiring the agency to do so; also, it does not indicate whether such guidance, if followed, would bar subsequent criminal or administrative action against the former employee. The DoD supplement to the OGE rule, called the Joint Ethics Regulation or JER, does not address this matter directly, although it does require each agency ethics counselor to provide advice and counseling to his DoD component command's employees on all ethics matters. Curiously, it does not specifically extend this responsibility to respond to former DoD officers or employees.

§207 contains no... guidance as to whether certain actions would violate the law...

The third relevant prohibition imposes a one-year ban on certain senior officers and employees engaging in representational activities with their former department or agency concerning any matter in which these persons are seeking official action by that department or agency. This restriction differs from the two previously discussed in several respects. It is limited to officers serving in the pay grade of 0-7 or above, or civilian employees whose basic pay equals that for Level V of the Executive Schedule. It is not limited to particular matters that these former officers or employees participated in or oversaw. However, it is limited to communications with one's former department or agency, and limits the term department or agency to one's former military department. A retired Army general, for example, would not violate this provision by acting in a representational capacity in discussions with the Navy.

5 C.F.R. §2637.212 establishes an administrative enforcement procedure which permits one's former agency, following the conduct of a hearing, to impose certain sanctions against the former employee for having violated the statute. Although the Ethics Reform Act (1989) repealed this authority, the regulation has

not been revised to reflect the change.

10 United States Code §2397b

This statute is commonly referred to as the Revolving Door Statute. It applies only to certain former military officers in the pay grade of 0-4 or above and former DoD civilian employees whose rate of pay is not less than the minimum rate of pay payable for grade GS-13 of the General Schedule. The rationale supporting this curiously worded limitation remains a mystery, but the law clearly applies to a former employee in the pay grade GS-12, Step 7. Another mystery is how the recently imposed geographical cost of living increases affect the law's reach. It does not speak in terms of the "basic rate" of pay for grade GS-13. The advent of geographical cost of living increases can result in extending the law's coverage. A GS-12, Step 6 in a high-cost area could earn more than a GS-13, Step 1 in a low-cost area. The law does not address this phenomenon. A second limitation is that a prohibited employer must be a contractor who in the preceding fiscal year received DoD contracts totaling $10,000,000 or more. The law was suspended for the same period of time that 18 U.S.C. §281 was initially suspended.

Since it is not applicable to all former executive branch employees, OGE has not issued implementing regulations; instead, the JER does this. Certain former officers or employees, provided various other criteria are met, are specifically prohibited from receiving compensation from certain government contractors. A basic distinction between this law and 18 U.S.C. §207 is that the former actually limits for whom the former employee may work whereas the latter merely limits the nature of the work one can perform for the employer. §2397b limits the scope of its coverage to activities conducted in the final two years of DoD service, ending with one's separation from service. The employment ban exists for a two-year period from the time one terminates federal service, although there is an available sanction, to be discussed later, which can extend this period.

Within the already limited group of DoD officers and employees there are three subgroups to which the act pertains. The last one described in the law is the most straightforward. That subgroup includes any person acting as the primary United States representative in negotiating a DoD contract exceeding $10,000,000 or negotiating an unresolved contractor claim in an amount in excess of $10,000,000.[2] No other limitations pertaining to the other two subgroups apply here. The employee is barred from receiving compensation from that contractor for two years after leaving DoD.

The other two categories concern otherwise qualifying former officers or employees who, on a majority of their working days in the final two years of DoD service, performed a procurement function. A procurement function is defined in the statute to include any function with respect to a contract relating to:

> (a) the negotiation, award, administration, or approval of the contract; (b) the selection of a contractor; (c) the approval of changes in the con-

[2] The statute specifies that the employee be the primary representative "in the negotiation of a settlement of an unresolved claim of the contractor in an amount in excess of $10,000,000 under a Department of Defense contract." It is not clear whether the $10,000,000 limitation applies to the settlement amount or the claim amount. It would seem as though Congress would have intended the limitation to be on the settlement amount, as that figure obligates the government. However, grammatically, the stronger argument appears to be otherwise.

tract; (d) quality assurance, operational and developmental testing, the approval of payment, or auditing under the contract; or (e) management of the procurement program.

Note how broadly the term is defined. In theory, someone assigned clerical duties in support of a source selection is performing a function under (b) above. The grade restrictions would probably eliminate such a person from the law's coverage, but this illustrates that this law does not require the personal and substantial involvement comprehended by 18 U.S.C. §207. The JER provides no helpful guidance as to what may or may not be a procurement function; it merely repeats the statutory definition. The JER is helpful, however, in limiting the term "working days" to those "actually worked, excluding holidays, weekends, sick days, and leave days of the two-year period in question." What remains is the question of whose responsibility is it to account for what the officer or employee does on those working days. Obviously, there would be no employee log available to establish this, or, should an employee maintain such, it would probably be unaccountably lost prior to an enforcement proceeding. The wording of the statute implies that one can be assigned responsibilities encompassing procurement functions and not necessarily be performing any of those functions on a daily basis. In other words, it cannot be presumed that one having procurement responsibilities performs a procurement function on any given working day. This is a decided shortcoming in the government's ability to enforce §2397b.

One of the two remaining subgroups include those performing a procurement function at a contractor owned or operated site or plant, which is the principal location of such person's performance of that procurement function. This appears to include persons assigned to the Defense Contract Management Command with a specific duty location physically on-site at a contractor plant and possibly persons, assigned to contract administration offices, whose primary responsibilities are carried out at a specific contractor plant or site. Since there can only be one principal location, in the latter case evidence of what that location was would seem to come from one's position description. If the position description did not state a specific contractor plant or site as the employee's principal location, either there would not be a principal location or, if so, it would be somewhere other than the contractor's plant. Periodic visits in a temporary duty status, regardless of how frequent, would not bring one within the coverage of this provision. At any rate, persons who do meet all these criteria may not accept compensation from the particular contractor at whose plant or site their procurement functions were performed. In addition, employment with that contractor is prohibited not only at that site or plant, but at any other site or plant owned or operated by that contractor, unless it is clearly not engaged in work on a DoD contract. The statute defines compensation as any payment or service exceeding a market value of $250.

....it cannot be presumed that one having procurement responsibilities performs a procurement function on any given working day.

The final subgroup includes those DoD employees performing procurement functions relating to a major defense system. This seems to apply typically to persons working in a systems program office, but it certainly is not limited to that situation. There are five distinctions between this and the subgroup just described. Initially, and this may be attributable to an oversight in drafting the legislation, the former category speaks in terms of performing "a procurement function," whereas this category spe-

cifically uses the term "procurement functions," implying that one must be performing more than one procurement function per day to come within the statute's prohibition. That Congress had such an intent is doubtful, but there is no explanation for the difference in the two provisions, one following directly after the other in the text of the law.

Second, this latter provision requires personal and substantial participation, something the former provision does not require. Neither the statute nor the JER defines the term. The JER merely adopts the OGE definition in 5 C.F.R. §2635.402(b)(4). That Code of Federal Regulations section does not implement 18 U.S.C. §207, but rather 18 U.S.C. §208.[3] Recall that 5 C.F.R. §2637.201(d) implements 18 U.S.C. §207 by defining the term "participate personally and substantially." The 5 C.F.R. §2635.402 wording is very similar to, but not precisely the same as, that in 5 C.F.R. §2637.201(d). It seems more logical for the JER to have incorporated by reference the definition in 5 C.F.R. §2637.201(d). That would assure DoD officers and employees that the term "personal and substantial" had precisely the same meaning under both 18 U.S.C. §207 as it does under 10 U.S.C. §2397b.

It is obviously a limiting factor, but we are left totally in the dark as to how limiting.

A third distinction is that the anticipation must involve "decisionmaking responsibilities." Unfortunately, neither the statute nor the JER provide any guidance as to what is meant by this term. It is obviously a limiting factor, but we are left totally in the dark as to how limiting. Certainly a system program manager and a contracting officer have decisionmaking responsibilities, and to some extent everyone assigned duties with respect to a defense system makes decisions. Yet how far into the bowels of the system program office Congress intended this responsibility to descend is anybody's guess. Can someone delegated authority by a contracting officer have decisionmaking responsibility? If so, does that responsibility depend on the nature and extent of the authority delegated? Do staff members involved in advising the decision maker have decisionmaking responsibilities? Can more than one person have decisionmaking responsibility for the same decision? Do all members of an award fee committee, for example, have decisionmaking responsibility? The guidance simply is unavailable to respond to these questions.

Next, this prohibition applies to "a contract for that (weapon) system." The acquisition of a major defense system entails a myriad of separate contracts entered into during the various phases of research and development, full-scale development, and production. The system itself encompasses all of its components, spare parts, and support equipment. Any contract to supply hardware or some technical service is a contract for that system. Yet the prohibition does not limit itself by its terms to the acquisition phase. Any support or maintenance contract for the already acquired system entails "procurement functions relating to a major defense system." The contract with which the federal officer or employee may have been involved is not necessarily, for example, the airframe manufacturer. Instead, it could be a contract to support aerospace ground equipment purchased as part of the overall system, and it could be entered into fifteen years after receipt of the final airframe under the production contract.

Finally, the DoD officer's or employee's

[3] 18 U.S.C. §208 concerns itself with conflicting financial interests of current federal employees, not the activities of former federal employees which may subsequently limit their representational capabilities.

conduct must involve "contact" with the contractor. The term "contact" suffers from all of the same difficulties associated with "decisionmaking responsibilities." There simply is no guidance as to how extensive Congress intended it to be. Certainly, contact would seem to include any direct written or oral communication, but does it include, for example, such communication through others? Further, how much direct communication is enough to satisfy the statute's prohibitions? Remember the "majority of the person's working days" requirement. Is a single contact in the final two-year period sufficient to trigger a violation of the law, as long as some or all of the other elements occur on a majority of the person's working days?

This then raises the question of whether all elements of the violation must occur on a majority of one's working days, or is it enough simply to have evidence of one element per day. The most sensible approach seems to be to view these different elements as a general description of the officer's or employee's duties, no one of which has to be performed daily. It would be sufficient to show that the general nature of the person's position entails these features, and that on a majority of that person's working days, he or she performed work of this nature. And again, whose responsibility is it to account for all these factors occurring? Neither the statute nor its implementing regulation give any hint that this is what Congress intended.

Another shortcoming stems from the so-called 30-day letter provision. Subsection (e) of the statute provides that anyone may request a written opinion as to whether the employment restrictions apply in his or her case. The request, based upon a complete disclosure of all relevant information, may be submitted to the appropriate designated agency ethics official (DAEO) who is to respond within 30 days of receipt of the request. The significance of the response is that a written opinion indicating the law is inapplicable to the submitter's particular situation will serve as a bar to any subsequent enforcement action. Because someone violating this statute is subject to a civil penalty not to exceed $250,000, and anyone offering or providing the compensation is subject to a $500,000 civil penalty, having such a written opinion could be viewed as the *sine qua non* of post-DoD employment. Following the law having become effective in 1987, there were many reports of prospective employers not being willing even to discuss employment possibilities unless the individual had a DAEO opinion. The problem lies in the full disclosure requirement. Based on the 30-day time limitation, a DAEO has to accept the representations in the request at face value. If the requester has taken certain license with respect to what his or her duties were in the final two years of DoD service, this will not be reflected in the DAEO opinion. That opinion is only as valid as the representations upon which it is based. Further, the effectiveness of the bar is specifically conditioned on the submitter making full disclosure. Those 30-day letters based upon less than full disclosure serve as no bar whatsoever; instead, what they may create is some false sense of security for employee and employer. It is more than a mere speculation that there exist a considerable number of invalid 30-day letters, given a competitive job market and the natural inclination to make oneself as attractive as possible to a future employer.

...there were many reports of prospective employers not being willing even to discuss employment possibilities...

41 United States Code §423

This statute, known as the Procurement Integrity Act, applies to all federal procure-

ment officials who solicited or accepted any promise of future employment from a competing contractor during the conduct of any agency procurement without having first obtained written permission to do so. It was suspended at the same time 18 U.S.C. §281 and 10 U.S.C. §2397b were also suspended. Unlike 18 U.S.C. §207, applying to all former employees, and 10 U.S.C. §2397b, applying only to certain DoD officers and employees performing specific functions, this statute applies, regardless of grade or rank, to persons because of their status as procurement officials, but only "during the course of any Federal agency procurement." It is key, then, to understanding this law that one appreciate who procurement officials are and when an agency procurement is considered as being conducted.

A procurement official does not even have to be a federal agency employee, but could be a contractor, subcontractor, consultant, expert, or advisor acting on behalf of the agency during the relevant period. For example, contractor employees providing source selection evaluation support services could be procurement officials. As the statute defines the term, however, someone having what would generally be regarded as procurement duties may be a procurement official with respect to certain contractual actions, and yet not an official with respect to other contractual actions. A procurement official must participate "personally and substantially" in one or more of the following activities concerning a particular contractual action: (a) draft the specification; (b) review and approve the specification; (c) prepare or issue the solicitation documents; (d) evaluate bids or proposals; (e) select sources; (f) conduct negotiations; (g) review and approve the award, modification, or contract extension; or perform such other function as may be specified in any implementing regulation.

Since the law's obvious emphasis is on the pre-award phase... modifications can be easily overlooked.

The Federal Acquisition Regulation (FAR), which implements the law, adds two types of activity: computing requirements at an inventory control entry point, and developing procurement or purchase requests. "Personally and substantially," as defined in FAR §3.104-49(g), tracks almost precisely the definition in 5 C.F.R. §2637.201(d).

The conduct of a procurement, within the meaning of the law, concludes with contract award or modification or cancellation. It applies following contract award only when a modification of the contract is being contemplated and then only until execution of that modification. Since the law's obvious emphasis is on the pre-award phase, this latter application to modifications can be easily overlooked. While the law specifies when the period ends, Congress was anything but clear about when it began, leaving that up to any implementing regulation. FAR §3.104-4(c) indicates the period begins on the earliest date "an identifiable, specific action is taken for the particular procurement," but in no event can it predate an authorized agency official's decision "to satisfy a specific agency need or requirement by procurement." There are exceptions. For broad agency announcements (not further explained) the procurement begins with the Commerce Business Daily publication; for small business innovative (SBIR) programs, the procurement begins when a solicitation is released for that SBIR program; for unsolicited proposals, it begins when a general statement of agency needs is published, when the agency responds to an inquiry as to what its needs may be, or the date of receipt of an unsolicited proposal, whichever is the earliest.

Merely being a procurement official with respect to a particular contract action does not disqualify one from engaging in discussions concerning future employment. The law only applies to employment discussions

with competing contractors. This entails a certain degree of prognostication on the part of the federal employee and others, since typically we think of competitors as those entities submitting bids or proposals. Since the law applies to the period before bid opening or receipt of offers, it expands the traditional definition of a competitor to include entities reasonably likely to become competitors for either the prime contract, or a subcontract under that procurement. Determining whether or not an entity is a competing contractor really is a judgment call in the absence of some clear, unequivocal statement on its part that it has no intention of participating in a certain contracting action. The FAR imposes a duty on both the procurement official and the competing contractor to verify the other's status prior to discussing future employment. However, in the context of post-federal employment limitations, the law is only concerned with actual competitors.

Certain restrictions apply once one qualifies as a procurement official for an agency procurement. These restrictions differ from what either 18 U.S.C. 207 or 10 U.S.C. §2397b impose. Recall that the former does not limit for whom the former federal employee may work, only the nature of what he or she does as a representative of that employer. The latter actually prohibits the former federal employee from working for certain government contractors. The Procurement Integrity Act does not prevent the former procurement official from being employed by a competing contractor. Rather, it imposes two 2-year restrictions on the nature of what one can do for that competing contractor. It is important to understand, however, that the two-year period does not begin with the procurement official's separation from federal service, as in 18 U.S.C. §207, but two years from the last personal and substantial participation. From a practical standpoint, this is a less serious restriction than that in 18 U.S.C. §207, but it creates a real problem in that it fails to provide the clear line of demarcation, creating thereby an enforcement problem. Presumably, in a civil action alleging a violation of the act, the government would have to establish when that last personal and substantial participation occurred. No enforcement action would impose this burden on the former procurement official. Just how the government might establish this date is anyone's guess. Congress would have been wiser to adopt the separation date to begin the two-year period.

The first two-year limitation prohibits the former employee from participating in any fashion, as a representative for a competing contractor, in "any negotiations leading to award, modification, or extension of the contract." This wording is in the statute itself. Negotiations leading to a modification or an extension can only occur between the government and the incumbent contractor. That part of the prohibition would seem to cause no problem. However, while negotiations between the government and the successful offeror lead to contract award, what about those negotiations between the government and an unsuccessful offeror? Are they negotiations also leading to award? Congress probably meant them to be such, but it is a little unclear whether Congress said that. Arguably, the former employee may not be violating the law by discussing employment with a losing competitor. From a practical standpoint, this sanction only applies to the contractor receiving the award.

...the former employee may not be violating the law by discussing employment with a losing competitor.

The second limitation pertains following award of the contract. The former employee may not participate personally and substantially in performing that contract. Proscribed conduct here differs from that under 18 U.S.C. §207 in that one can partici-

pate personally and substantially on behalf of a contractor without engaging in any type of representational activities. What is prohibited here is personal and substantial involvement on behalf of the contractor after having already participated personally and substantially in the conduct of the same contractual action on behalf of the government. Again, the sanction only has practical effect on the successful competing contractor.

The Procurement Integrity Act is a highly complex piece of legislation, various parts of which may by enforced by contractual penalties under subsection (g), administrative actions under subsection (h), civil penalties under subsection (i), and criminal penalties under subsection (j). Criminal penalties may be imposed only for disclosing proprietary data to a competing contractor, a matter not relevant here. Contractual remedies available to the government, including denial of some or all profit under the awarded contract and termination for default, apply where the procurement official either solicits or accepts a gratuity from a competing contractor, engages in employment discussions with a competing contractor, or provides proprietary data to a competing contractor. These likewise do not apply to the situation in which the procurement official goes to work for a competing contractor.

Congress' choice of words here is unfortunate.

Civil remedies are available against both the former federal procurement official and the competing contractor using his or her services. A civil penalty of no more than $100,000 may be imposed on the individual, and no more than $1,000,000 on the competing contractor. This is really the only sanction against the individual. It requires the government to establish, by a preponderance of the evidence, that the individual was (a) a procurement official, (b) whose last personal and substantial activity as a procurement official occurred less than two years prior to the (c) allegedly improper personal and substantial conduct as an employee or representative of the competing contractor.

The available administrative remedies are also limited to actions against the competing contractor. The statute specifically authorizes the agency to initiate suspension and to consider debarment. Those actions are relatively straightforward. The statute also states that where a contract has not been awarded, the agency shall determine "whether to terminate the procurement." Congress' choice of words here is unfortunate. The word "terminate" in government contracting refers to certain remedies available to the government once a contract has already been awarded. It is a word of art. What Congress probably meant, in terms familiar to those engaged in government contracting, was to cancel the procurement or resolicit. The statute also indicates that voiding or rescinding the contract may be appropriate.

The law contains a "30-day Letter" authority similar to that in 10 U.S.C. §2397b, permitting a federal employee or former employee to obtain a written opinion, to be provided within 30 days of the request, from a DAEO concerning the law's applicability to the requester's circumstances. However, unlike the 10 U.S.C. §2397b written opinion, an opinion rendered pursuant to the Procurement Integrity Act does not serve as a bar to future government enforcement action. One has to wonder why the written opinion in the one case should have greater validity than in the other. The difference can only serve to mislead those affected by the Procurement Integrity Act into believing their written opinions have the same legal effect as those issued pursuant to the Revolving Door Statute. In all fairness the two provisions should be consistent, either barring or not barring subsequent enforcement action.

Reform

The Section 800 Panel, commissioned by the FY91 National Defense Authorization Act, conducted an extensive review of the federal statutes governing conflicts of interest. It recommended that 10 U.S.C 2397b be repealed in its entirety, concluding the administrative burden on DoD far outweighed any benefit. The panel further recommended that 41 U.S.C. §423(f), imposing the post-federal employment restrictions, also be repealed. Instead, the panel proposed an amendment to 18 U.S.C. §207 restricting the former employee's use of nonpublic information. Specifically, the panel recommended that a former employee, meeting the personal and substantial test in the statute with respect to a procurement within the final year of his or her public service, and having had access to information concerning that procurement exempt from public disclosure under the Freedom of Information Act, could not represent, aid, or assist anyone other than the United States concerning that procurement for one-year after leaving federal service. 18 U.S.C. §207 does not presently prohibit such conduct, and the Revolving Door Statute and the Procurement Integrity Act only limit such conduct on the part of a small number of persons.

Many of the Section 800 panel recommendations were incorporated into S1387, known originally as the Federal Streamlining Act of 1993, introduced by Senator John Glenn (Ohio). However, FASA contains none of the three recommendations mentioned directly above. The Glenn Bill represented the best opportunity to take advantage of the Section 800 panel's work. Congress has indicated it will again consider conflicts of interest legislation during the present session. Yet, without the past momentum for reform, we seem destined to live with this mass of confusing, inconsistent legislation for some time to come.

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