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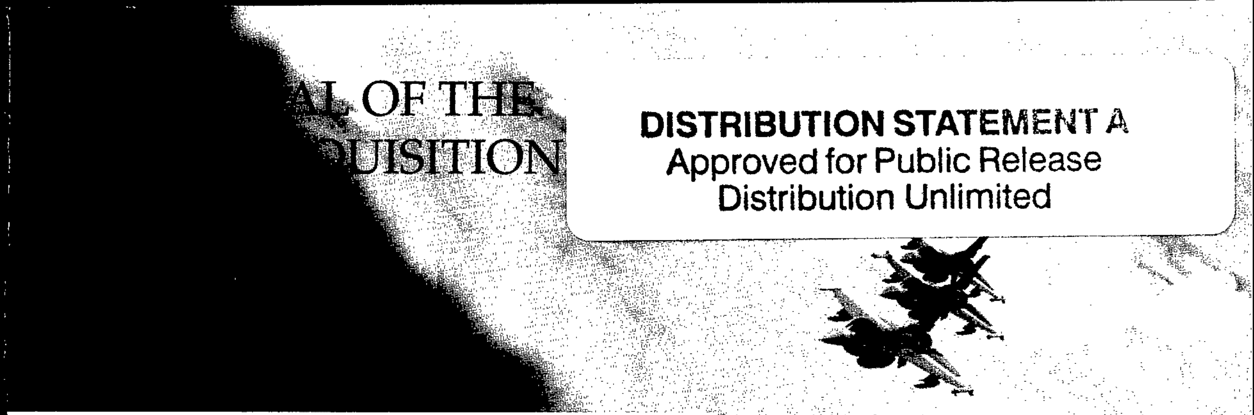

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CORRECTIONS: Please note the following corrections to the Spring 2003 edition of the *Acquisition Review Quarterly* journal.

The correct e-mail address for Marie Smith on p. 114 is msmith@EDO-Services.com.

The correct wording on p. 208, Table 1, under the heading "Numerical Designation, subhead IV, should state, "May cause *less than* minor bodily injury, minor occupational illness, or minor damage to a bodily system."

The correct e-mail address for George R. Murnyak on p. 214 is george.murnyak@apg.amedd.army.mil.

TUTORIAL

Opinion

261 - INVESTIGATING THE INTEGRATION OF ACQUIRED FIRMS IN HIGH-TECHNOLOGY INDUSTRIES
IMPLICATIONS FOR INDUSTRIAL POLICY

Maj David R. King, USAF and Lt Col John D. Driessnack, USAF

Acquisition activity persists despite evidence that acquisitions do not improve firm performance. Further, government policy toward the defense industry has advocated consolidation in the name of nominal cost savings. We explore the role acquisitions play toward technology transfer and begin to identify factors associated with acquisition success through a review of existing research on post-acquisition performance that primarily considers acquiring firm stock performance. Using this research as a foundation, we build a model to analyze post-acquisition performance using a sample of high-technology firms. Results suggest critical success factors associated with post-acquistion stock performance are poorly understood. We conclude that proactive government policy toward high-technology industry mergers and acquisitions may be misguided due to difficulty in predicting acquisition outcomes.

285 - WHY THE "T" IN SMART
A CONSTRUCTIVE SYNERGY

LTC Michael D. Proctor, USA (Ret), Amy Posey-Macalintal, and Dennis Kulonda

Department of Defense (DoD) simulation-based acquisition (SBA) is widely discussed in literature. The Army offers a broad vision of SBA concept in the form of Simulation and Modeling for Acquisition, Requirements, and Training (SMART), accenting not only the Acquisition process but also essential contributions from the Requirements and Training communities. This research highlights how organizational training simulation has significantly helped the acquisition process beyond the confines of post-acquisition training.

Lessons Learned

301 - LESSONS LEARNED FROM THE EARLY STAGES OF DEVELOPMENT OF THE GUARDRAIL COMMON SENSOR FOR THE RADICAL REDUCTION OF CYCLE TIME

J. Daniel Sherman

Nine key participants from the government and prime contractor were interviewed to identify important lessons learned from the early stages of development of the Guardrail Common Sensor. In addition to in-depth interviews, U.S. Army Communications and Electronics Command (CECOM) historical documents, unclassified government reports, and other public sources were reviewed for information regarding the system's development. The management of the system development deviated from normal acquisition processes in several important ways. These are presented and the implications for flexibility in the acquisition process are discussed.

Summer 2003

Photo taken by Neville Dawson

THE USE OF OFFSETS IN FOREIGN MILITARY SALES

Lt Col Robert L. Waller, USAF (Ret)

United States defense firms have increasingly encountered demands from their foreign buyers to provide compensation for selecting U.S. suppliers. These quid pro quo transactions, also known as *offsets*, compensate the buyers for the economic *damage* caused by purchasing costly U.S. defense equipment. While these offsets may appear to be solely a form of price cutting, the motives of the foreign buyers can be varied. The behavior of these buyers can be explained by economic incentives ranging from labor market distortions and desires for foreign investment to the need for international financing. In most cases, it appears that offset transactions are a form of commercial policy that the buying governments use to address domestic problems. Defense industry personnel will likely encounter offset transactions and will benefit from a better understanding of the buyers' motivations.

In the 1980s, I studied and wrote about the use of offsets in defense sales to foreign governments.[1] (The term *offsets* is used in defense sales to mean the compensation given to foreign buyers, by U.S. sellers, to *offset* the economic impact on the foreign buyers from having purchased U.S. made items, rather than domestically-produced items.) Since the time of that writing, the defense environment has undergone significant changes with the end of the Cold War and the breakup of the Warsaw Pact, mergers within the defense industry, and the changing level and nature of the threat. With a changed defense environment, there is a need to reexamine the issue of offsets and to validate the economic explanations of why buying nations request, and even demand, offsets when purchasing foreign-made defense items.

To gain an understanding of the current environment surrounding offsets in the defense industry, officials in the industry were contacted and, when willing, questioned about their experiences.[2] Because of the proprietary nature of the information, and the fact that competitions involving offsets are currently ongoing, few specifics can be identified in this article; however, the general motivations behind the use of offsets are presented.

Offset agreements appear to be common in large defense sales of aircraft, radars, and other electronic systems, to foreign governments. In fact, it appears that offset agreements are the norm in such transactions. In a typical offset arrangement, the buying country (who most likely has a formal offsets policy or even a law governing offsets)[3] requires the selling firm to provide economic offsets or compensation for having purchased the particular foreign-made system or items. The offsets may include purchases by the selling firm from the buying nation, as well as marketing assistance for, investments in, or technology transfers to the buying nation. The seller may also agree to produce a portion of the product in the buyer's country. The value of the offsets expected by the buying nations frequently equals the value of the original defense purchases, and the time required to fulfill the offset commitments may easily exceed the delivery time for the purchased defense equipment.[4]

"It appears that the current competitive environment in the worldwide defense industry dictates that a selling firm must anticipate offering offsets to the buyer to have any reasonable chance of winning a sale."

It appears that the current competitive environment in the worldwide defense industry dictates that a selling firm must anticipate offering offsets to the buyer to have any reasonable chance of winning a sale. With the frequent use of offsets, it is logical to ask, what motivates a buying nation to request or require offsets? Why would a buyer choose this type of transaction, a purchase contract accompanied by an offset agreement, when a simpler, more straightforward cash deal is available and might result in a cheaper price for the defense item? An initial response might be that the buying nation has some monopsony power and the nation uses that power in a competitive environment to win an effective price reduction. While this may be true in some cases, it is also reasonable to assume that in many cases the selling firms have to cover the costs of fulfilling their offset commitments and thus must increase the prices of the defense items accompanying these commitments.[5]

If the latter is true, and firms do increase the prices of the defense items in order to cover the offsets' costs, then the purchase and combined offsets package can be equated to a form of subsidization. The buyer pays more than a straight cash price, and in return receives certain benefits (discussed below). The alternative for the buyer would be to pay a lower price for the required defense items and then provide the subsidization for the desired benefits directly out of public funds. However, the direct subsidization may not be possible due to political constraints. Thus, offsets may be considered a form of indirect subsidization, and possibly a second-best, or blunt form of government intervention or commercial policy.

The Motives

Discussion of some of the motives that buying countries may have when they require offsets from foreign suppliers of defense equipment follows. These motives go beyond that of obtaining an effective price cut, and, in several cases, appear to be efforts to subsidize certain activities.

Corrections in the Labor Market

A buying country may face a situation where an excessively large pool of unemployed labor exists in the country, or a significant percentage of its workforce is in low-skilled industries. Either case may justify some form of government action. Stimulative macroeconomic policy, elimination of the minimum wage, or a reduction in barriers that hinder the mobility of labor (from, say, union power or government regulations), might address the first situation. A subsidy program targeting certain industries could be used to increase employment in high-skilled areas, thus addressing the second case. However, political constraints may prevent the use of some of these actions. Thus, a government might seek other ways to address the labor market problem, and an offset agreement might be part of the solution.

Through an offset arrangement, the buying government can increase its exports and thus stimulate employment. In particular, the government can require the selling firm to agree to buy products produced in the buying country, or to establish certain co-production and subcontracting relationships with local firms. The buying government can, therefore, ensure that certain components or tasks associated with desired high-tech skills be produced in its local economy, thus not only increasing employment in general but increasing the skill level of a portion of the workforce.

The use of offsets could be viewed, in an economic setting, as a form of government intervention in response to a distortion in the local labor market. In the hypothetical cases described above, perhaps the minimum wage, excessive union power, or government-imposed barriers are causing unemployment in the local economy. However, due to political constraints these factors may be well entrenched in the nation, and perhaps the offsets package is a second-best method of addressing the distortion in the labor market; the first best being removal of the distortion itself. Additionally, in the case where there is a lack of high-skilled employment opportunities, the government's use of offsets could be in lieu of, say, a politically-charged direct subsidy to selected high-technology firms to encourage employment in those industries.

"National leaders often desire to see an increase in investment activity in their countries."

Anecdotal evidence supports this theory of the use of offsets. Industry officials report that it is common for countries to include in their offset requirements a list of general categories of technologies that are desired, and to discuss specific technologies during negotiations. To encourage employment in certain targeted industries or in depressed regions, the buying nations may award selling firms additional offset credit for purchases made from those industries or from firms within the designated regions.

Enhance Capital Investment

National leaders often desire to see an increase in investment activity in their countries. This activity would bring an increase in employment, particularly in targeted advanced skills, and, in the case of developing countries, an increase in national pride from the expanded capital stock. The usual macroeconomic tools available to policymakers to encourage an increase in investment are those associated with monetary policy, such as an easing of interest rates or credit conditions, or some type of stimulative fiscal policy, such as an investment tax credit. In addition, policymakers might use direct subsidies to specific industries to promote investment activity. However, once again, these tools may not be suitable or available.

"Oftentimes governments give selected industries a favored status."

The use of stimulative monetary and fiscal policies might be restricted because of domestic inflation concerns or worries about the budget deficit. Using direct subsidies, given only to targeted industries, would likely cause political problems; industries not subsidized would feel *left out*, and labor might feel that handouts to industry were too generous. Therefore, national leaders could use offset agreements to provide stimulus to investment activity while avoiding political friction.

In the offset negotiations, the buying government can request that the selling firm build a production facility in the buying country or use its influence to encourage other domestic firms, such as subcontractors, to do so. In this way, the buying government sees an increase in capital investment, without the political problems associated with a direct subsidy scheme. Since the selling firm must recoup the cost of the possible sub-optimal investment decisions by increasing the price of the defense equipment, the offsets arrangement may be viewed as an indirect subsidy scheme. The buyer pays a higher price for the defense item, but receives the desired investment activity.

Industry officials report that in addition to the desired capital investment, buying governments, recognizing their limited domestic demand to absorb the new output, often expect assistance with marketing the output from these new facilities in third countries. Thus, an offsets agreement may not only call for capital investment in the buying nation, but also marketing assistance for the output; thus making the facility a viable project from the very beginning. An interesting twist to this arrangement is when the selling firm builds a facility in the buying country and then is able to use this facility to create a new marketing channel for itself, perhaps providing parts and components to service the facility.[6]

Promote Strategic Industries

Oftentimes governments give selected industries a favored status. This special status may be due to political reasons, specifically a desire for military self-sufficiency. To support these targeted industries, government policymakers may call for subsidy payments to the firms to ensure their viability. However, these direct and overt subsidies can cause political problems. Industries not selected for support may complain about the discriminatory subsidies. Labor groups not associated with the targeted firms may also complain. Critics of government intervention will likely find fault with the use of public funds to assist selected private industry or to support inefficient public firms. To avoid these political battles and still obtain the desired subsidization, government leaders may turn to offsets.

Similar to the scenario above, when policymakers want to increase employment in certain high-technology industries, offset agreements can be structured to channel business toward the targeted firms, including the award of extra offset credit for purchases made from these selected firms. Again, this use of offsets mimics a subsidization scheme. If it is assumed that the offset-granting firm raises the price of its defense items to cover the cost of providing the offsets, then the buying government is providing an indirect, and less visible, form of subsidization to the targeted industries.

Correct for Asymmetric Information

A government's use of offsets can also be viewed as a reaction to the existence of asymmetric information. First, many of the major defense firms have well developed worldwide marketing networks and expertise, while the nations buying their products lack the extensive marketing skills needed to promote their own countries' exports. Second, most of the buying nations of defense items have a need to increase their technological bases, while the firms selling them defense items are leaders in a variety of technologies. Both of these cases represent situations of asymmetric information; the sellers possess information that the buying nations desire, that is, marketing expertise and state-of-the-art technologies.

In both the situations described here, offset agreements can be used to correct the information gaps. A buyer of defense items can request that the selling firm assist in marketing the buying nation's products to new customers, using the firm's extensive marketing network, including the contacts of its subcontractors. The buyer may also award offset credit for the value of technological information that is transferred, possibly through training programs, to the buying country. In this manner, the buying nation has taken corrective action to address the existence of asymmetric information, improving its marketing expertise and its technological base; and, in the case of the marketing assistance, the nation has reduced some of the transaction costs associated with its exports.

Reduce Risk and Uncertainty

Economic theory usually assumes that agents, for a given return or level of output, prefer to reduce risk whenever possible. This assumption applies to government policymakers also. As an example, decision makers in a country may wish to reduce the risk and uncertainty associated with a large capital investment, say, some type of production facility. Specifically, they may be concerned that sufficient demand for the output of the new facility is lacking, and thus the large project will fail, embarrassing the country, putting government funds at risk, and increasing unemployment.

"Economic theory usually assumes that agents, for a given return or level of output, prefer to reduce risk whenever possible."

In a situation such as this, these government policymakers could use offsets to reduce the risk and uncertainty associated with the highly visible project. By identifying the products from the facility in the targeted list of items for the defense firm to help market, the government officials could increase the likelihood of success for the project in return for offset credit. As in the earlier offsets incentives discussed above, this use of offsets could be seen as another form of subsidization. Here, the buying government may pay a higher price for the defense items, but in return gets assistance in marketing the products from a politically sensitive project, thus reducing the associated risk.

"Policymakers in the buying country may see the use of offsets to win the needed political support as a form of commercial policy."

Provide Alternative Financing

Political leaders in a nation may see the need for foreign-made defense items for their country, but may feel constrained due to an imbalance in their country's Balance of Payments. Specifically, the nation may already have a severe deficit in its trade balance, and the purchase of the foreign-made defense equipment would only aggravate the deficit. Therefore, there might be an economic, as well as a political, barrier to the purchase. Once again, offsets may provide a solution for the policymakers' dilemma.

By requiring, in the accompanying offset agreement, the selling firm to purchase an equal monetary value of domestic goods and services, the buying nation can avoid worsening its trade imbalance, and, in a fixed exchange rate regime, protect the nation's foreign exchange reserves. Here, the use of offsets seems to approximate a sophisticated form of barter. The goods and services are exchanged with no net effect on the currency balances of the two countries.

There is an interesting extension to this line of reasoning for the use of offsets when we introduce the connection to barter. Occasionally there have been media reports of the use of sophisticated barter arrangements to conceal the prices of exports. This is most applicable when the nation is a member of a cartel-like organization such as Organization of Petroleum Exporting Countries (OPEC), or possibly the International Coffee Agreement. The scenario has the buying nation knowingly purchasing the foreign-made items at inflated prices, and in return, selling the oil, coffee, or whatever, at the official, cartel approved price. In this manner, the country's leaders have effectively cut the price of the commodities without openly breaking with the other members of the cartel.[7]

Gain Political Support

In an effort to win domestic support for a large defense-related purchase from a foreign firm, the buying government may tout the many benefits the nation will enjoy from the offsets received. By publicizing the increase in exports and associated employment gains, as well as any new capital investments, co-production arrangements and technology transfers, political leaders in the purchasing nation will hopefully dampen domestic criticism of the purchase.

Policymakers in the buying country may see the use of offsets to win the needed political support as a form of commercial policy. Here they are intervening to correct for an externality; the defense items have a social value greater than the perceived market value.

Conclusion

Transactions involving large defense purchases from U.S. firms by foreign governments most often involve offset agreements between the selling firms and the buying governments. Policymakers in the buying nations can use the offset agreements to address a variety of economic and political issues within the buying countries. The desired effects identified were: labor market corrections, promotion of capital investment, support for strategic industries, adjustments for asymmetric information, reduction of risk and uncertainty, alternative sources of financing, and political support for defense purchases. In some of these situations, the use of offsets appears to be an alternative form of commercial policy, replacing a more direct form of intervention.

Recently provided information from industry appears to validate the work done in the 1980s. The changes in the defense environment over the past two decades do not seem to have changed the motives behind the use of offsets. However, according to comments from industry officials, the frequency of the use of offsets, as well as the size of the offset requirements (as a percentage of the transaction value) both appear to have risen. Offsets are a reality of the existing competitive nature of the marketplace. Understanding the economic incentives leading to their use is helpful not only to U.S. policymakers but also to industry officials.

Professor Robert L. Waller, Lt Col, USAF (Ret) is an associate professor of economics at the U.S. Air Force Academy. Waller earned his A.M. degree at the University of Michigan and his Ph.D. in economics at Boston University. His research has dealt with countertrade and information superiority.

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ENDNOTES

1. See, for example, "Why Offsets?" *Program Manager*, November–December 1989.

2. The majority of my updated information came from an industry official who has worked offset programs in over ten countries over the past decade.

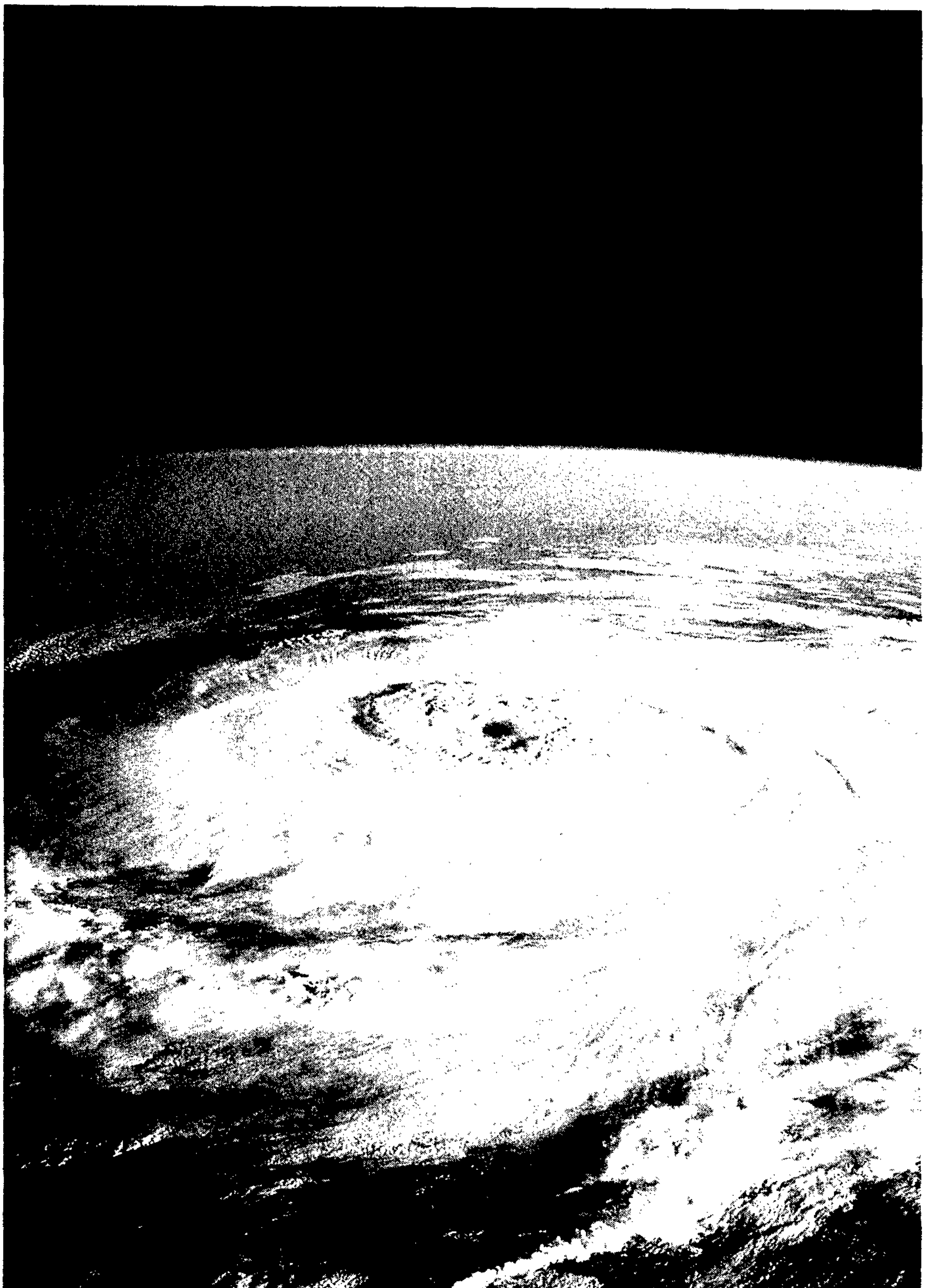
3. An example of such a policy is Australia's requirement for foreign information technology-related companies wishing to supply information and communication technology goods and services to the Government of Australia to export Australian goods and services, to transfer technology, and to engage in research and development in Australia. See, for example, *2001 Country Reports on Economic Policy and Trade Practices*, published by the Bureau of Economic and Business Affairs, U.S. Department of State, February 2002.

4. While foreign governments often have laws or policy statements outlining their offset expectations, the U.S. Government's policy, as stated in Federal Acquisition Regulation (FAR) 225.7303, is that the Department of Defense does not get involved with a defense firm's offset commitments. The decision to engage in offsets, and the responsibility for fulfilling offset commitments, is purely the firm's.

5. The pricing guidelines for Foreign Military Sales contracts in FAR 225.7303-2 support this assumption.

6. A hypothetical example of this might be where a U.S. defense firm, as part of its offset commitment to a buyer, builds a plant in a buyer's country to manufacture some parts for final assembly back in the U.S. or in some third country. The newly built plant, however, requires very specialized components, machinery, and technological assistance, all of which must be provided by the defense firm's primary facilities back in the United States.

7. For examples of OPEC's use of barter-type transactions during the mid-1980s see: Youssef M. Ibrahim, "Crumbling Cartel OPEC's Old Iron Grip on World Oil Prices becomes Ever Weaker," *The Wall Street Journal*, January 11, 1985, pp. 1, 9; and, "Oil-for-Planes Accord Is Likely for UAE, France," *The Wall Street Journal*, October 1, 1984, p. 37.



THE TRANSFORMATION OF CONTRACT INCENTIVE STRUCTURES

Robert Graham

The National Polar-orbiting Operational Environmental Satellite System's Acquisition and Operations contract for the next generation of weather satellites uses innovative incentive structures to motivate contractor performance. The incentive approach combines an award fee and mission success fee arrangement to include a cost mitigation approach, putting fee at risk and tying corporate executive pay to contract performance. This business approach is complemented by a shared ownership approach to the development and production of the satellites. These innovative approaches give the government the flexibility to share system responsibility while motivating the contractor toward outstanding performance on the contract.

In the current acquisition environment of transforming from traditional to streamline acquisition approaches, there are many innovative strategies being proposed by organizations to incentivize contractor performance. The following discussion will look at the program approach and contract incentive structure for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program's Acquisition and Operations (A&O) contract. Figure 1 is a graphic representation of the NPOESS satellite system.

The A&O contract uses a dual approach, a Shared System Performance Responsibility (SSPR) approach to the program with an incentive structure that combines an award fee and mission success fee arrangement to include a cost mitigation approach, putting fee at risk and tying corporate executive pay to contract performance. The clauses on contract and the comprehensive Award Fee and Mission Success Fee Plan allow for the contractor to receive interim award fee payments while working toward the full incentive fee. This innovative approach gives the government the flexibility to share system responsibility while motivating the contractor toward outstanding performance on the contract.

PROGRAMMATICS

The NPOESS program is a presidentially-directed tri-agency program chartered to converge the separate Commerce, Defense, and National Aeronautics and Space Administration (NASA) environmental

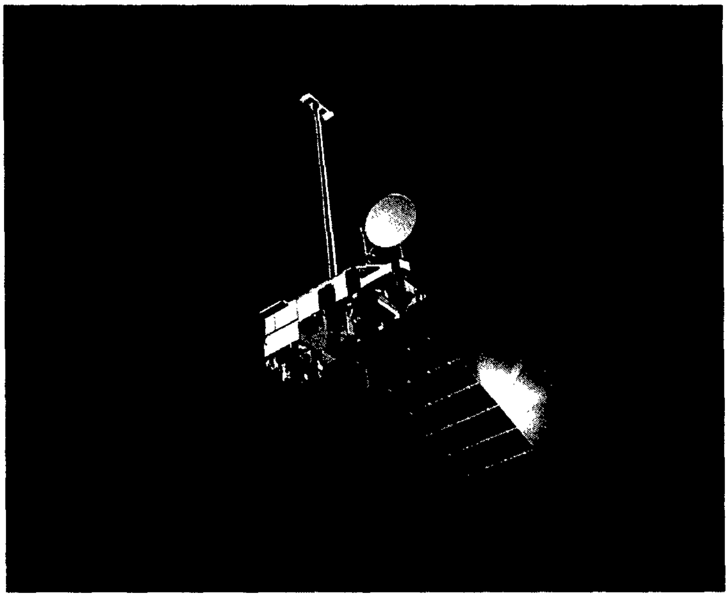


Figure 1. Photo of NPOESS

satellite programs into a single program. Figure 2 defines the Tri-Agency Relationship. A tri-agency Memorandum of Agreement (MOA) signed at the cabinet level directs the Department of Commerce (DOC) to be the lead agency for program management for the converged program, directs the use of Department of Defense (DoD) acquisition procedures, and tasks NASA to provide technology support.

The NPOESS satellite is the next generation weather satellite with state-of-the-art technologies and the A&O contract is the innovative vehicle to accomplish

- Department of Commerce, through National Oceanic and Atmospheric Administration (NOAA), will have lead agency responsibility for the converged system. The Department of Commerce (DOC) will report to a tri-agency executive committee. NOAA will provide the System Program Director and an Integrated Program Office (IPO).
- National Aeronautics and Space Administration (NASA) will have lead agency responsibility to support the IPO in facilitating the development and insertion of new cost effective technologies that enhance the ability of the converged system to meet its operational requirements.
- Department of Defense will have lead agency responsibility to support the IPO in major system acquisitions necessary to the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program.

Figure 2. Tri-Agency Relationship

the successful development, production, and launch of these satellites. The NPOESS program integrates the capabilities and products provided by the DOC Polar-orbiting Operational Environmental Satellite (POES) Program, the DoD Defense Meteorological Satellite Program (DMSP), and the NASA long-term continuous climate record collection. This single converged system will satisfy the needs of defense, civil, commercial, and the scientific communities.

The program ended a Preliminary Design Risk Reduction (PDRR) phase with the award of the A&O contract. In addition, the NPOESS Integrated Program Office (IPO) conducted a Phase 0 development from early 1995 through December 1999 and has had a series of ongoing sensor development programs that started in 1997. The Phase 0 development and PDRR phases competitively awarded contracts for state-of-the-art sensor technology that would be used on the NPOESS satellite. The PDRR contractors were competitively down-selected to one contractor for completion of the engineering and development effort for each sensor. These sensor contracts were subsumed as subcontracts by the A&O contract with a single prime contractor having overall system performance responsibility.

The Phase 0 development efforts were mainly cost-type risk reductions, and the PDRR contracts were a mix of fixed-price and cost-incentive line items accounting for the complexities and uncertainties of these efforts, which were not conducive to pre-negotiated-objective incentives. The program's award fee instrument for the PDRR efforts provides a level of flexibility and oversight, which is desirable given the developmental characteristics of these acquisitions. Furthermore, the award fee process was established to have a significant impact toward motivating the contractor to perform exceptionally. All of these efforts were designed to reduce development risk during Engineering, Manufacturing, and Development (EMD). These efforts culminated with the completion of the Preliminary Design Review (PDR) for both satellite PDRR contracts and award of a single A&O contract.

Contractual Overview

The NPOESS A&O contract has two unique features that bring substantial innovation to the acquisition process: (1) an innovative award fee plan that includes mission success fee arrangements, and (2) Shared System Performance Responsibilities. The EMD portion of the contract has a Cost-Plus-Award-Fee (CPAF) arrangement with base fee, award fees, and mission success fees; and the production portion has a Fixed-Price–Incentive (firm target) (FPIF) arrangement with award fees and mission success fees. These contract types were selected based on analysis of program risks.

> **"This single converged system NPOESS will satisfy the needs of defense, civil, commercial, and the scientific communities."**

Three types of fees exist in the EMD Phase. They are a base fee (2 percent of the estimated cost), an award fee (13 percent of the estimated cost), and a mission success fee (5 percent of the estimated cost). Whereas, in an FPIF arrangement, used in the production phase, there is a target profit at 10 percent of target cost of each replenishment satellite, a 50-50-share ratio for overruns and underruns, and a ceiling price of 135 percent of target cost, award fee (5 percent of target cost), and mission success fee (5 percent of target cost).

The base fee under the EMD phase will be used to help the contractor provide some cash flow stability. The award fee for both the EMD phase and production efforts of the contract is intended to incentivize continuous contractor responsiveness to program priorities and place emphasis on quality processes.

The mission success fee criteria has been developed to reward the contractor for achieving specific, demonstrable program objectives that are critical program events during the EMD phase of the contract, while the mission success fee criteria developed for the production FPIF incentive will incentivize the contractor to meet cost targets and specific program events.

"All the fee or profit earned in the EMD phase and production efforts is earned at risk."

Finally, a fee risk covenant clause is included in the contract. All the fee or profit earned in the EMD phase and production efforts is earned at risk. That is, fee is earned by and paid to the contractor during contract performance, but the government may recoup some fee/profit if the system (for the EMD effort) or the replenishment satellites (for the production effort) do not meet performance goals.

The A&O contract also has unique incentive clauses to address the following areas:

1. **Shared System Performance Responsibility (SSPR).** The prime contractor is responsible for SSPR and undertaking all actions necessary for ensuring that the overall performance of the NPOESS satellites meets all requirements as described in the A&O contract. This concept will be discussed in depth below.

2. **Cost Mitigation Incentive.** A cost mitigation incentive is used to encourage the contractor to prepare and apply cost mitigation initiatives. The contract allows the contractor to submit cost mitigation incentive proposals for the government's review and acceptance. Where an initiative results in real savings to the contract, the savings are shared between the parties.

For each production option on contract, the contractor proposed a firm target price, and the government will have the unilateral right to exercise the option at that price, at the appointed time. However, since this price will likely include some factor for risk that might not materialize by the time the option is exercised, the government wanted to incentivize the contractor to manage and reduce the risk to the government with an expectation of renegotiating a lower target price as reasonable. The cost mitigation concept is an improvement over value engineering for this program by giving better insight on *acquisition savings* and *collateral savings* than proposed by Federal Acquisition Regulation (FAR) 48. This incentive structure will be discussed in depth.

3. **Fee Risk Covenant.** Although the contractor may earn fee during the course of this contract, the award fees and mission success fees earned during the EMD phase of the contract are earned at risk. Similarly, the fixed-price-incentive profit (or fee), award fees, and mission success fees earned during the production efforts on each replenishment satellite are also earned at risk. This means that although the contractor has possession and use of earned fee, to retain possession of the fee it must produce a system that provides useful service over the satellite's life. This incentive structure will be discussed below.

4. **Performance Inputs to Senior Executive Compensation.** This clause is an effort to decrease cost overruns on major contracts, "which typically run 18 percent over budget — costs that the Defense Department pays for" (Merle, 2002, p. E5). This contract is the first to use this new Air Force initiative. "The provision in the contract won't force executives to take a pay cut, but requires TRW's (aquired by Northrop Grumman on December 12, 2002) board to consider contract performance when setting top executives' salaries and bonuses" (Merle, 2002, p. E5). In essence, the clause in the NPOESS A&O contract would require TRW to present to the corporate board on a semi-annual basis information about Northrop Grumman's performance on the NPOESS A&O contract. According to the *Washington Post*, "the Air Force is the only part of the Pentagon to propose linking performance to executive pay" (Merle, 2002, p. E5). This innovative clause is one part of the incentive structure of the NPOESS A&O contract aimed at increasing the contractor's accountability for contract performance.

5. **Base Fee.** A special clause under section B includes a provision of a base fee as an incentive to the contractor. The contractor may invoice monthly for an amount equal to one twelfth of that fiscal year's base fee amount.

Shared System Performance Responsibility

The key to the successful business, programmatic, and contractual relationship under the NPOESS A&O contract is SSPR. The innovative concept and the centerpiece to the A&O contract is the SSPR clause. The SSPR clause states for performance responsibility, "The contractor shall have SSPR for the entire NPOESS (NPOESS A&O Contract, 2002)." SSPR means that the contractor is responsible for undertaking any and all actions necessary for ensuring that the overall performance of NPOESS meets all contract requirements. For NPOESS, SSPR includes integration of all segments, systems, subsystems, and components whether furnished by the government, identified and directed by the government, managed by the government

"The key to the successful business, programmatic, and contractual relationship under the NPOESS A&O contract is Shared System Performance Responsibility."

or its designated agent, or commercially acquired. Additionally, the contractor is responsible for ensuring that the NPOESS [satellite] is optimized for post-EMD production, deployment, and support (NPOESS A&O Contract, August 22, 2002, p. 28).[1]

Integration responsibility under SSPR includes the monitoring of all associate contractor and government systems and infrastructure activities. Monitoring includes the timely notification and recommendation of mitigation efforts to the government for risks resulting from schedule, technical, or resource conflicts with these systems and infrastructure activities to ensure the contract schedule, NPOESS system specification, and integrated master plan requirements are met by the contractor. Under the SSPR clause:

> The contractor accepts performance responsibility whether or not individual segments, systems, subsystems, or components are fabricated, manufactured, or assembled by the contractor, a subcontractor (notwithstanding that any such subcontractor may have been selected pursuant to any provision hereof), or furnished as government-furnished property (GFP). (NPOESS A&O Contract, August 22, 2002, p. 28)

The contractor is fully responsible for the integration of all systems, subsystems, and components whether GFP or commercially acquired, installed and integrated into the NPOESS system without any degradation of performance of that item or in the overall system performance, and all required inspection and acceptance test procedures are accomplished and sufficient to meet specifications and performance requirements. The contractor's responsibility to install and integrate subsystems and components without degradation of performance is in addition to, and not in substitution of, its responsibility to insure that the total system will meet all requirements of the system specification.

The SSPR clause also includes provisions for an equitable adjustment if failures of any external systems or infrastructure requiring interface with the NPOESS satellite does not meet stated capabilities. This does not relieve the contractor of SSPR, as the contractor is required under the contract to avoid or mitigate any impacts to the NPOESS satellite to the maximum extent practicable. However, the SSPR clause does state:

> The parties agree that equitable adjustments may be made to the cost, schedule, NPOESS contract system specification, fee criteria and other affected terms and conditions of the NPOESS contract for NPOESS impacts resulting from changes to external systems or infrastructures requiring interface with NPOESS capabilities. (NPOESS A&O Contract, August 22, 2002, p.28)

The basic concept of total system performance responsibility is met through a shared ownership approach. SSPR does not eliminate government oversight of key important parameters, or cost and schedule issues. The government continues to have successful insight into the contractor's operations while maintaining the critical oversight of program issues. The innovation of SSPR, having open communication to facilitate insight into the program's decision making, and an integrated management framework to improve visibility, has reengineered how the government views total system performance responsibility. The NPOESS programmatic and business arrangement adapts to the changing acquisition environment and institutes SSPR as a means of establishing a government and contractor partnership that reflects the government's expectations with significant incentives focused on the highest program risks to create a win-win situation.

SHARED OWNERSHIP CLAUSE

The contractor accepts SSPR through the life of the contract. To complement the SSPR clause[2] is a shared ownership clause that defines the SSPR relationship more fully.

With the relationship under the SSPR clause established above, the NPOESS program office and the contractor have adopted the concept of shared ownership — a relationship between government and industry where risk and returns are shared. This management approach depends upon highly integrated management teams to ensure adequate government insight and oversight while maintaining SSPR by industry. This partnership is implemented through a shared ownership clause. The shared ownership clause states:

> The foundation of the NPOESS acquisition strategy is based on three guiding principles: a solid understanding of program business risks, awareness of industrial base concerns, and shared ownership. Even with award of the NPOESS A&O contract, these three principles will continue to exist and shall be encompassed by the concept of shared ownership. Shared ownership is defined as the integrated management framework between the IPO and SSPR contractor that provides the foundation for program performance consistent with these principles and the requirements of this contract. (NPOESS A&O Contract, August 22, 2002, p. 29)

The program office and the contractor work together under the basis of the clause to ensure teamwork, trust, open communications, and consultation with each other on program decisions that impact the team's ability to execute the program. The clause states that:

> Contractor performance will be evaluated against the obligations set forth in this contract including modifications to this contract. Award fee or incentive fee evaluations will be made in accordance with the provisions of the contract. The IPO will conduct evaluations that reflect the effect of the government's actions on the performance of the integrated management team. (NPOESS A&O Contract, August 22, 2002, p. 29)

To facilitate the shared ownership concept through the life of the A&O contract, the program office and contractor will engage in a quarterly dialogue.

The purpose of this dialogue is to maintain executive focus on program performance and evaluate the IPO and contractor team's effectiveness in achieving the desired program results. At the close of each government fiscal year quarter, the IPO and contractor program directors jointly prepare an agenda for executive dialogue to be conducted by their respective executives (NPOESS A&O Contract, 2002, p. 29).

The A&O contract has the highest visibility within the contractor's organization to facilitate these discussions and relationships. As mentioned above, there is also executive pay tied to the successful contractor performance. This total package of incentives assists with the complete understanding of the SSPR concept under the NPOESS A&O contract.

"To facilitate the shared ownership concept through the life of the A&O contract, the program office and contractor will engage in a quarterly dialogue."

In addition, there are Integrated Product Team (IPT) relationships addressed under the concept of shared ownership. Under the shared ownership clause, "The contractor shall invite the IPO to assign government officials (or supporting Federally Funded Research and Development Center [FFRDC] employees) on the contractor's IPTs. The IPO may or may not make such assignments (NPOESS A&O Contract, August 22, 2002, p. 29)." Where these assignments are made, they are for the purpose of providing visibility into the contractor's performance and progress, and insight to the contractor from the government. The clause goes on to say,

> [G]overnment officials (or supporting FFRDC employees) do not chair IPTs, and the presence and participation of government officials on an IPT does not indicate government acceptance or concurrence on any matter presented to the IPT. Government participation does not in any way relieve the contractor of responsibility for total system performance under this contract. (NPOESS A&O Contract, August 22, 2002, p. 29)

> [Also, the] Contracting officer shall be the only individual authorized to redirect the effort or in any way modify any terms of this contract. The contractor shall not rely on any direction or instruction from any other government team member that is contrary to the contract or that increases or decreases the scope or estimated cost of the contract. Insight and information provided to the contractor by other members of the government team is provided for the contractor's benefit and use as it sees fit to accomplish its total system performance responsibilities under this contract. (NPOESS A&O Contract, August 22, 2002, p. 29)

The NPOESS program provides an opportunity to redefine how government and industry cooperate to procure and deliver goods and services. Shared ownership offers the potential to harness the efficiency of commercial practices to significantly reduce the cost of major system acquisitions. The basis of shared ownership, as stated above, allows IPO participation in

IPTs for visibility and insight into the contractor's performance and progress. However, this participation does not relieve the contractor of overall system performance. In an effort to promote better management of this tri-agency program, in conjunction with motivating the contractor's performance, the concept of SSPR and shared ownership was developed to improve communication between the contractor and the government. This improved management concept will assist in managing the design and production of the next generation weather satellites.

INNOVATIVE AWARD FEE PLAN[3]

INTERIM AWARD FEE PAYMENT AND ADJUSTMENT

There are three areas that encompass award fee: (1) interim award fee payments, (2) mission success incentives, and (3) fee at risk. Ancillary to this incentive structure is a cost mitigation incentive that is also key to motivating the contractor to reduce costs. For the interim award fee payments, the government *may* make monthly interim award fee payments to the contractor. These fee payments shall not exceed 80 percent of the award fee amount available for each evaluation period, and are prorated on a monthly basis. The determination and the methodology for determining the amount of award fee billable are unilateral decisions made solely at the discretion of the government based on contractor performance. Adjustment of the interim award fee payments, to reflect and account for the actual award fee earned and awarded for the evaluation period, has an elaborate mechanism for fairness of the award fee process.[4]

If the cumulative amount of interim award fee payments made during an evaluation period is less than the total award fee determined to have been earned or awarded for that period, the contractor is required to submit a separate invoice for the additional amount and the government will pay the balance of the award fee earned under the terms of the award fee clause.[5]

If, for any reason, the cumulative amount of interim award fee payments made during an evaluation period exceeds the total award fee determined by the government to have been earned or awarded for that period, the government shall deduct or offset the overpayment from subsequent fee and, if necessary, costs incurred. To assist the government in this regard, the contractor is required to reflect such adjustments on subsequent invoices. For purposes of FAR clause 52.232-17, *interest*, the due date for any refund to be made by the contractor is the date of the first written demand for payment. This interim award fee payment process complements the incentive fee arrangement on contract.

"[T]he government may make monthly interim award fee payments to the contractor."

Industry stressed the importance of two financial elements when developing the strategy for the A&O contract: profit and cash flow. Several contracts within the Air Force have used the interim award fee payments to improve the contractor's cash flow, foster a healthy relationship between the government and industry, and further the benefits of the award fee incentive. The intent of the interim award fee payment business arrangement was to motivate contractors to perform well and gain momentum in the initial award fee period, allow heightened responsiveness to program areas of interest and concern, provide contractors with reasonable cash flow on a major systems acquisition, and leverage the overall award fee period incentive in terms of avoidance of the contractor having to repay the interim award fee with interest. This incentive seeks to motivate the contractor to effectively make business decisions, facilitate communication at all levels within the program, and promote flexibility in the contractor's internal incentive programs. The incentive looks to heightened awareness and responsiveness to problems, action plans, and to promote teamwork within the integrated product teams making them more effective through early detection rather than reactionary to program issues.

"The controversy of interim award fee payments is the perceived statutory restrictions that advance payment of public monies is prohibited unless properly approved."

Cash flow concerns are mitigated by the interim payments and the government is fully protected by the Fee Determining Official (FDO) oversight of the process. The guidelines are clearly established in the award fee and mission success fee plan, and refunds are required if performance was not as favorable as determined during the period.

In the true sense of promoting acquisition reform within the acquisition community, the NPOESS program stepped out with its initiative to improve a recognized critical business arrangement by providing interim award fee payments on the A&O contract.

The controversy of interim award fee payments is the perceived statutory restrictions that advance payment of public monies is prohibited unless properly approved. This prohibition is found at 31 United States Code section 3324 that states, "Except as provided in this section, a payment under a contract to provide a service or deliver an article for the United States government may not be more than the value of the service already provided or the article already delivered." The basic meaning of the statute is that if the money has not been *earned*, it cannot be paid. The comptroller general has interpreted the statutory precursors (Section 3648, Revised Statutes, and 31 United States Code 529) to 31 United States Code 3324 as not preventing a partial payment in any case in which the amount of such payment has actually been earned by the contractor and the United States has received an equivalent therefore, i.e., corresponding benefit. (See, 1 Comptroller General 143, 145 [1921]; 47 Comptroller General 89 [1977]).

The interim award fee procedure under the A&O contract conforms to the comptroller general criteria because it allows the contractor to bill periodically for an established percentage of available award fee during each evaluation period. The point that the payment was "actually earned by the contractor" is pertinent here. It is reasonable to view award fee as earned by the contractor daily, the precise amount of which is not determined until the end of the period. The award fee is not determined daily, but over a greater period of time, to make reasonable administration possible. The A&O contract uses the following logic for their interim award fee approach; first, the contractor has performed and can therefore be considered to have earned some portion of profit or fee. Then second, final pricing straightens out any under or overages.

The interim award fee payment is authorized only after an assessment by the FDO that the contractor's performance warrants interim payments. The historical thinking as to why award fee could not be the subject of some type of interim billing related to the need for, and finality of the FDO's decision. As long as the FDO's ability to make an independent decision is preserved and the contractor accepts the fact that it might end up repaying some amount based on the FDO's decision, there is no reason why the same logic as that supporting interim billing of other fees would not apply. Any overpayment or underpayment will be rectified after the FDO's independent decision. There is no precedent that would make repayment under the A&O contract any more problematic than correction of an administrative overpayment or erroneous payment.

The award fee and mission success fee plan sets forth the criteria for interim award fee payments as discussed above. Interim award fee is predicated upon contractor performance. Interim award fee provides quantifiable time value of money advantages to the contractor. However, it should be noted that the NPOESS program uses the interim award fee provisions judiciously with consideration given for unusual cash flow concerns from the contractor, the length of the award fee periods, and the expected benefits to the acquisition.

In summary, the NPOESS program's philosophy holds that contractors are earning award fee throughout the award fee period. Paying a percentage of the fee on their regular billing cycle at a rate that is unlikely to result in overpayment would not constitute an advance payment. In the unlikely, unintended event the contractor is paid at a rate ultimately determined to exceed its entitlement; the difference could be recouped as an overpayment or erroneous payment. The award fee and mission success fee plan was drafted to maximize contractor cash flow, government obligation rates while minimizing government resources of administration, and odds of overpayment.

"Cash flow concerns are mitigated by the interim payments and the government is fully protected by the Fee Determining Official (FDO) oversight of the process."

The interim award fee payment helps the contractor offset cash flow problems associated with performing this major multi-billion dollar program. The concern about cash flow was very important to the program office based on input from industry and consideration of other major satellite program's histories of cost overruns. This advantageous incentive structure allows the contractor to focus more on achieving the program elements than cash flow issues and payment procedures. By adopting this incentive structure, the intent was to maintain a healthy contractor relationship and incentivize the contractor to focus on contract performance for developing and producing the next generation of weather satellites.

AWARD FEE AND MISSION SUCCESS FEE PLAN STRUCTURE

The comprehensive award fee and mission success fee plan is the basis for the government's award fee and mission success fee evaluation of the contractor's performance under the A&O contract for the EMD phase and production efforts. The award fee and mission success fee plan implements Air Force Materiel Command Federal Acquisition Regulation (AFMCFARS) clause 5352.216-9003, and together these two elements apply significantly new innovation to this contract.

This contract includes two types of incentive fees in the award fee and mission success fee plan. The first is award fee. The second is the mission success fee. Both are award fee constructions and the award fee and mission success fee plan covers the process for both fees. Award fee incentivizes the contractor's management approaches, technical excellence, and cost control efforts on an on-going, period-by-period basis. Mission success fee incentivizes the contractor's realization of certain specific achievements that are critical to the success of the program.

"The interim award fee payment helps the contractor offset cash flow problems associated with performing this major multi-billion dollar program."

The FDO solely determines the award fee and mission success fee amounts earned. These incentive structures give the government program director program flexibility and latitude to reward results during contract performance. Both award fee and mission success fee are further divided between the development and production efforts of the contract. The development effort is the design, development and deployment of the system, including operations and support, through the declaration of Initial Operational Capacity (IOC). The production effort is for replenishment satellites for the program life. The award fee and mission success fee earned under this plan are earned at risk as described in the clause for fee risk covenant that will be discussed below.

The award fee plan is set up such that there are two separate authorities that authorize payments. The FDO is the government official (for the NPOESS Program the FDO is the program director) designated to determine the amount of award fee and mission success fee earned and payable to the contractor. The FDO also makes rollover decisions. Rollover of fee is the ability of the FDO to authorize unearned fee from the current fee period, whether award fee or mission success fee, into subsequent fee periods. The FDO may also authorize interim mission success fee payments. In contrast to the FDO responsibilities, the Award Fee Review Board (AFRB) chair may only authorize interim award fee payments in accordance with the "interim award fee payment and adjustment" clause and the award fee and mission success fee plan and section 7 of the award fee and mission success fee plan.

Determination of the earned award fee and mission success fee is inherently subjective. The contractor's assessment of its own performance, assessments produced by government performance monitors, the knowledge of the AFRB and FDO, and the criteria specified in the plan form the basis for the recommendations of the AFRB and determinations by the FDO.

As discussed above, the incentive structure is set up so the AFRB chair may authorize interim payments of award fee, but it is only the FDO that may authorize one or more interim payments of mission success fee. The FDO may authorize interim mission success fee payments at the one, two, and three-year points, so long as the cumulative value of these interim payments do not exceed the mission success incentive percentages shown in the award fee and mission success fee plan. Interim mission success fee payments are like interim award fee payments and are subject to government recoupment if the final FDO fee determination for the mission success event is less than the amount authorized as interim fee.

The award fee and mission success fee plan also have a provision for rollover of award fee. The FDO may allow rollover of unearned award fee into subsequent award fee periods. The FDO may allow rollover of unearned mission success fee into the following events or into new events. The purpose of the interim payments and rollover of fees to subsequent periods is two-fold: (1) to allow the contractor the use of the fee, which is substantial for a major satellite program, during the period, and (2) to motivate the contractor's performance by allowing the contractor the opportunity to earn the unused fee in a subsequent period where it is in the government's best interest to do so based on program risks and objectives. While these incentives have been discussed and tested on numerous government contracts, the incentive structure under the NPOESS A&O contract formalizes the government's ability to use these incentives to motivate the contractor on a major satellite program.

This transformation for contract performance incentives is accomplished through a shift in how the organization processes award fees and mission success fees. The contract performance incentive transformation seeks to implement a new concept for award fee and mission success fee plans by using the interim payments of fees in conjunction with having those fees at risk to motivate performance. The transformation of award and mission success fees under this contract is a substantial improvement to the comprehensive and flexible fee system for achieving, sustaining, and maximizing business success. The key concepts for the success of the award fee and mission success plan are: (1) a close understanding and a clear definition of customer needs for the contractor, (2) the understanding of contractor cash flow problems based on prior history of other satellites and similar satellites program's histories through the review of data and statistical analysis to ensure, in the case of the NPOESS program, the best value for the government under this plan, with (3) diligent attention to managing, improving, and reinventing business practices to ensure a fair fee incentive structure. This award fee and mission success fee plan does not replace the traditional Air Force award fee or mission success fee plans but adds to these concepts to create further innovation in the award fee incentive structure.

"Rollover of fee is the ability of the FDO to authorize unearned fee from the current fee period, whether award fee or mission success fee, into subsequent fee periods."

RISK FEE COVENANT CLAUSE

The risk fee covenant clause[6] is associated with the incentive fees on contract. Although the contractor will earn incentive fees during the course of this contract, the award fee and mission success fee earned during the EMD phase of the contract are earned at risk. Similarly, the fixed-price-incentive profit, award fee, and mission success fee earned during the production efforts on each replenishment satellite are also earned at risk. This means the contractor has earned the fee; however, the contractor may have to return up to 100 percent of the fee if it fails to provide a system that provides useful service. Under this incentive structure, the FDO will make assessments according to the *risk fee covenant* clause to retire fee at risk. The FDO will consider the inputs and suggestions of the contractor in the assessment, but the final decision is the FDO's subjective decision.

"The award fee and mission success fee plan also have a provision for rollover of award fee."

For the EMD phase, the assessments are on overall system performance. There is a complicated formula for the three fee risk removal periods as stated in the contract clause,

The fee risk removal pool for this period [initial] is equal to the award fee and mission success fee on the EMD CLINs [Contract Line Item Number] earned to that point. Up to one tenth of this risk may be removed at each six-month risk retirement assessment based on the FDO's subjective assessment of overall system performance during the previous six-month period. The FDO's assessment will be a numerical percentage between 100 percent and 0 percent, where 100 percent = completely successful and 0 percent = completely unsuccessful. The fee risk removed at that instance is a factor of the FDO's assessment percentage against the one-tenth figure available at that decision.... The fee risk removal pool for this period [second] is equal to the EMD award fee and mission success fee earned to that point, less the fee risk removed during the initial period. This means any fee risk not removed in the initial phase may yet be removed during the second phase. Up to one-tenth of this risk may be removed at each six-month risk retirement assessment based on the FDO's subjective assessment of overall system performance during the previous six-month period.

The fee risk removed at each assessment is factored in the same manner as during the initial period described above.... The final fee risk retirement period for the EMD phase starts with the second assessment after the IOC declaration and runs until all fee risk is removed. The fee risk removal pool for this period is equal to all the award fee and mission success fee earned during the EMD phase, less the fee risk removed during the initial and second periods. This means any fee risk not removed in the initial and second periods may yet be removed during the final phase. Up to one-tenth of this risk may be removed at each six-month risk retirement assessment based on the FDO's subjective assessment of overall system performance during the previous six-month period. The fee risk removed at each assessment is factored in the same manner as during the initial period.

Under the production phase for each production option, fee risk reduction is also a complicated formula, as stated in the contract:

> The fee risk removal pool for this period [initial] is equal to the actual profit arrived at through application of the fixed-price-incentive arrangement, the award fee, and the mission success fee attributable to that satellite (however, it does not include the cost mitigation incentive, if any). Up to one-fourteenth of this risk may be removed at each six-month risk retirement assessment based on the FDO's subjective assessment of the satellite's success during the previous six-month period. The FDO's assessment will be a numerical percentage between 100 percent and 0 percent, where 100 percent = completely successful and 0 percent = completely unsuccessful. The fee risk removed at that instance is a factor of the FDO's assessment percentage against the one-fourteenth figure available at that assessment.... The final fee risk retirement period starts with the assessment immediately following launch of the satellite and continues until all fee risk is removed. The fee risk removal pool for this period is unchanged from the initial period. Up to one-fourteenth of this risk may be removed at each six-month risk retirement assessment based on the FDO's subjective assessment of the satellite's success during the previous six-month period. The fee risk removed at each assessment is factored in the same manner as during the initial period and if the FDO fails to make a fee risk reduction assessment in January or July of any year, the contractor may treat this as a favorable 100 percent success assessment for that period. (NPOESS A&O Contract, August 22, 2002)

That last statement is important because it puts the onus on the government to manage the contract and maintain adherence to the criteria for retiring the fee. This clause measures and analyzes the fee structures put at risk on this contract. Attachment 4 to the NPOESS Request For Proposal gave a detailed, quantitative analysis of the risk fee covenant clause as follows:

Initial Fee Risk Removal Period

Sample figures are shown below:

- $50,000,000 award fee earned through December 2006.
- $25,000,000 mission success fee earned through December 2006.

Step one — Determine the fee risk removal pool for the initial period. This is the sum of the award fee and mission success fee earned through the start of the period. In this example, it is $75,000,000.

Step two — Determine the amount available for fee risk removal at each six-month decision. This is one-tenth of the fee risk removal pool. In this example, it is $7,500,000.

Step three — The FDO performs an assessment at each six-month decision, and the fee risk removed is the assessment factored against the amount available for risk removal at that decision. In this example, a 100 percent success assessment will retire risk on $7,500,000; a 90 percent success assessment will retire risk on $6,750,000; an 80 percent success assessment will retire risk on $6,000,000, and so forth. An illustrative initial period is provided below in Figure 3, Fee Risk Removal — Example 1. This shows an example where the FDO made 100 percent success assessments in January 2007, January 2009, and July 2009, with 50 percent success assessments in every other period.

It should be noted that it is not possible to remove the risk on the entire risk removal pool during the initial period. The portion where the risk is not yet removed rolls over into the second fee risk removal period and becomes part of the second period.

SECOND FEE RISK REMOVAL PERIOD

Sample figures are shown following:

- $72,500,000 award fee earned through December 2009 (includes the $50,000,000 earned in the initial period).
- $37,500,000 mission success fee earned through December 2009 (includes the $25,000,000 earned in the initial period).

Step one — Determine the fee risk removal pool for the second period. This is the sum of the award fee and mission success fee earned through the start of the period (including the fee earned during the initial period), less the fee risk removed during the initial period — in this example, the earned fee is $110,000,000 and the fee risk removed during the initial period is $33,750,000, so the fee risk removal pool for the second period is $76,250,000.

Step two — Determine the amount available for fee risk removal at each six-month decision. This is one-tenth of the fee risk removal pool. In this example, it is $7,625,000.

Step three — The FDO performs an assessment at each six-month decision, and the fee risk removed is the assessment factored against the amount available for risk removal at that decision. In this example, a 100 percent success assessment will retire

	Jan 2007	Jul 2007	Jan 2008	Jul 2008	Jan 2009	Jul 2009
Available:	$7,500,000	$7,500,000	$7,500,000	$7,500,000	$7,500,000	$7,500,000
FDO Assessment:	100%	50%	50%	50%	100%	100%
Fee Risk Removed:	$7,500,000	$3,750,000	$3,750,000	$3,750,000	$7,500,000	$7,500,000
Cumulative Removal:	$7,500,000	$11,250,000	$15,000,000	$18,750,000	$26,250,000	$33,750,000

Figure 3. Fee Risk Removal — Example 1

risk on $7,625,000; a 90 percent success assessment will retire risk on $6,862,500; an 80 percent success assessment will retire risk on $6,100,000, and so forth. An illustrative second period is provided below in Figure 4. This shows an example where the FDO made 100 percent success assessments in January 2007, January 2009, and July 2009, with 80 percent success assessments in every other period.

It should be noted that this example presumes IOC in September 2011, but it could occur earlier or later — in such a case, this period could have more or fewer decisions than illustrated here.

Final Fee Risk Removal Period

Sample figures are shown below:

- $100,000,000 award fee earned through December 2009 (includes the $72,500,000 earned in the initial and second periods).

- $50,000,000 mission success fee earned through December 2009 (includes the $37,500,000 earned in the initial and second periods).

Step one — Determine the fee risk removal pool for the final period. This is the sum of the award fee and mission success fee earned through the start of the period (including the fee earned during the initial and second periods), less the fee risk removed during the initial and second periods. In this example, the earned fee is $150,000,000 and the fee risk removed during the initial and second periods is $67,300,000 ($33,750,000 and $33,550,000, respectively), so the fee risk removal pool for the second period is $82,700,000.

Step two — Determine the amount available for fee risk removal at each six-month decision. This is one-tenth of the fee risk removal pool. In this example, it is $8,270,000.

Step three — The FDO performs an assessment at each six-month decision, and the fee risk removed is the assessment factored against the amount available for risk removal at that decision. In this example, a 100 percent success assessment will retire risk on $8,270,000; a 90 percent success assessment will retire risk on $7,443,000; an 80 percent success assessment will retire risk on $6,616,000, and

	Jan 2010	Jul 2010	Jan 2011	Jul 2011	Jan 2012
Available:	$7,625,000	$7,625,000	$7,625,000	$7,625,000	$7,625,000
FDO Assessment:	100%	80%	80%	80%	100%
Fee Risk Removed:	$7,625,000	$6,100,000	$6,100,000	$6,100,000	$7,625,000
Cumulative Removal:	$7,625,000	$13,725,000	$19,825,000	$25,925,000	$33,550,000

Figure 4. Fee Risk Removal — Example 2

so forth. A table for the final period is not provided, but the mechanics are identical to those illustrated in the initial and second period examples above. The period will continue with six-month decisions until the entire fee at risk is retired.

The transformation of the contract performance incentive structure established by this clause looks at ways to incentivize the contractor to present an operational system to the government as proposed at contract award. This clause gains significant benefits to both the government and contractor and is established using a fair incentive structure to retire fee at risk to motivate the contractor's performance.

"The final pillar for the incentive structure is an equally innovative element known as the cost mitigation incentive clause."

COST MITIGATION INCENTIVE CLAUSE

The final pillar for the incentive structure is an equally innovative element known as the cost mitigation incentive clause.[7] The contractor is encouraged to submit cost reduction initiatives to the government for review and approval. For any initiative incorporated into the contract by modification, the contractor is entitled to share in the contract savings resulting from the implementation of the initiative. The clause requires that each cost mitigation initiative be significant in nature and be beyond the scope of the cost control expectations of the award fee incentive. Acceptance of any cost mitigation initiative is entirely at the government's discretion. However, the contractor's share of savings shall be the cost mitigation incentive, should the government accept any cost mitigation proposals. The incentive is not considered fee for purposes of the award fee and mission success fee plan of this contract and is not subject to fee risk retirement.

The cost mitigation incentive only applies to the production effort of the A&O contract. For each production option on contract at the time of contract award, the contractor proposed a firm target price. The government will have the unilateral right to exercise the option at that price, at the appointed time. However, since the price at contract award will likely include some factor for risk that might not materialize during the performance of the contract, the government wanted to incentivize the contractor to manage and reduce the risk so that as the option exercise time approaches, the parties could agree that a lower target price as a cost and risk mitigation. Under this scenario, the contractor would, at its discretion, submit a proposal with a lower target price to renegotiate the option price(s). The proposal would include details of the assumptions and analysis upon which the new proposal is based for the government's consideration. The government already has insight to the contractor's cost and risk at contract award for the production options on contract; however, the new proposal would detail any risk reduction activities and cost mitigation to the production option(s).

After a comprehensive review by the government, the parties may agree to modify the contract to reflect the new lower target price. The terms and conditions of the option under renegotiation would remain unchanged with the contractor's incentive being that if the government concurs with the proposal, the contractor receives 50 percent of the difference between the original option target price and the new lower target price. The government still has the ability to exercise the current option on contract at the agreed upon price.

Under the scenario where the current option is exercised without any cost mitigation, and the contractor reduces cost, the contractor still has the share ratio to net profit for the cost mitigation efforts. The key to the cost mitigation incentive is timing of receiving the profit and cash flow. If the contractor submits a cost mitigation proposal and the government accepts the downward revision, the contractor receives the incentive at exercise of option instead of after performance. There is also an immediate savings to the government since obligations would be reduced by the incentive amount. If the contractor eventually overruns, the ceiling price and share ratio are applied for reduced costs and profit as applicable to the option pricing.

The cost mitigation incentive clause complements the award fee and mission success fee plan to form a solid incentive fee structure for the contract. While the cost mitigation incentive clause seems like a revised value-engineering clause, in essence cost mitigation incentives reinvented the meaning of value engineering for this program by giving better insight on *acquisition savings* and *collateral savings* than proposed by FAR 48. The acquisition savings for this contract are under the production options, giving an immediate or instant contract savings over current units and potential future production units if the proposal is accepted. This immediate savings is tangible and seen in the reduction of option prices; where in the traditional value engineering proposal, the savings are less tangible because of the formula and allowable costs for value engineering savings. By eliminating the complex formulas and transforming the traditional value engineering process into a new business process, the program office has in fact changed the way the government formulates a savings under the A&O contract. The savings is real and apparent.

The same holds true for collateral savings whereby costs of operation, maintenance, logistic support, or government-furnished property are reduced by the option price reduction without a reduction in scope of the option. The intentions of this incentive are to enable the government to obtain insight into the contractor's pricing of its FPIF production options, including the risk assumptions built into the target price. This process should also incentivize the contractor to manage these risks before option exercise and take mitigating steps to reduce the target cost of the option before it is exercised. By using these innovative concepts to incentivize the contractor, the NPOESS program is transforming the way the Air Force and the DOC conduct contract administration. These innovations look to increase productivity, decrease cost overruns, and provide the government with a best value satellite system for the next generation of weather satellites.

"The key to the cost mitigation incentive is timing of receiving the profit and cash flow."

SUMMARY

NPOESS has initiated an innovative transformation from the traditional contract performance incentive structure to motivate contractor performance. The program has reinvented the award fee and mission success fee plans into a comprehensive incentive package with interim payment methods using global contracting concepts tailored to individual use in the NPOESS' acquisition strategy. The A&O contract for the development and production of the next generation weather satellites has adapted to the current acquisition environment with select innovations in business practices such as establishing a base fee, interim award fee payments, cost mitigation incentives, and risk reduction incentives to reduce cost overruns and increase productivity, with an SSPR and shared ownership concepts for technical competencies. The incentive structure under the A&O contract is a comprehensive and flexible system for achieving, sustaining, and maximizing programmatic, business, and acquisition success.

"The cost mitigation incentive clause complements the award fee and mission success fee plan to form a solid incentive fee structure for the contract."

The A&O contract offers industry the opportunity to realize commercial rates of return. The EMD portion of the contract will use cost reimbursement line item structure with a base fee to ensure adequate cash flow for successful program execution; an award fee that provides substantial returns for successful technical, schedule and cost management; and mission success fees awardable on achievement of significant program events and on-orbit performance. The production portion of the contract will use a fixed price incentive line item structure. During production, cost control is incentivized through a 50/50 share ration, successful technical and schedule management is recognized through an award fee, and system reliability and durability rewarded through on orbit incentives.

The SSPR approach reinvents the total system performance responsibility concept to a shared ownership concept to increase productivity and bring a *quality first* approach to the technical and business arrangements of the acquisition process. The NPOESS program provides an opportunity to redefine how government and industry cooperate to procure and deliver goods and services. The NPOESS program office has created the concept of shared ownership, a relationship between government and industry where risk and returns are shared. This management approach depends upon highly integrated management teams to ensure adequate government insight and oversight while maintaining total system responsibility by industry. Shared ownership offers the potential to harness the efficiency of commercial practices to significantly reduce the cost of major system acquisitions.

By looking at new ways of doing business in the government, many organizations develop success stories; however, the NPOESS program has set up such a new and innovative incentive structure that it is revolutionizing the way the DoD and DOC approach future acquisitions.

The many long hours developing these approaches cannot go unspoken without mentioning the consent and advice the program received from key procurement officials within the Air Force, DoD, NASA, and DOC. It is through teamwork and partnership among government agencies that NPOESS can truly be counted a success. The future of weather forecasting is counting on the success of the NPOESS A&O contract and the innovative incentive structures on contract to implement the state-of-the-art technologies for weather forecasting in the new millennium.

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ACRONYMS

A&O – Acquisition and Operations

AFMCFAR – Air Force Materiel Command Federal Acquisition Regulation

AFRB – Award Fee Review Board

CLIN – Contract Line Item Number

CMIS – Configuration Management Information Systems

CPAF – Cost-Plus-Award-Fee

CPCM – Certified Professional Contracts Manager

DOC – Department of Commerce

DoD – Department of Defense

DMSP – Defense Meteorological Satellite Program

EMD – Engineering, Manufacturing, and Development

FAR – Federal Acquisition Regulation

FDO – Fee Determining Official

FFRDC – Federally Funded Research and Development Center

FPIF – Fixed-Price-Incentive-(Firm Target)

GFP – Government-Furnished Property

IOC – Initial Operational Capacity

IPO – Integrated Program Office

IPT – Integrated Product Teams

MOA – Memorandum of Agreement

NASA – National Aeronautics and Space Administration

NCMA – National Contract Management Association

NOAA – National Oceanic and Atmospheric Administration

NPOESS – National Polar-orbiting Operational Environmental Satellite System

PDR – Preliminary Design Review

PDRR – Preliminary Design Risk Reduction

POES – Polar-orbiting Operational Environmental Satellite

SSPR – Shared System Performance Responsibility

ENDNOTES

1. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Special Contract Requirements Clause H-500, "Shared System Performance Responsibility (January 2002)."

2. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Special Contract Requirements Clause H-503, "Shared Ownership (January 2002)."

3. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Award Fee and Mission Success Fee Plan.

4. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Special Contract Requirements Clause H-519, "Interim Award Fee Payment and Adjustment (January 2002)."

5. The Award Fee Clause is AFMCFAR Clause 5352.216-9003.

6. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Special Contract Requirements Clause H-521, "Fee Risk Covenant (January 2002)."

7. NPOESS Acquisition and Operations (A&O) Contract. (August 22, 2002). Special Contract Requirements Clause H-524, "Cost Mitigation Incentive (January 2002)."

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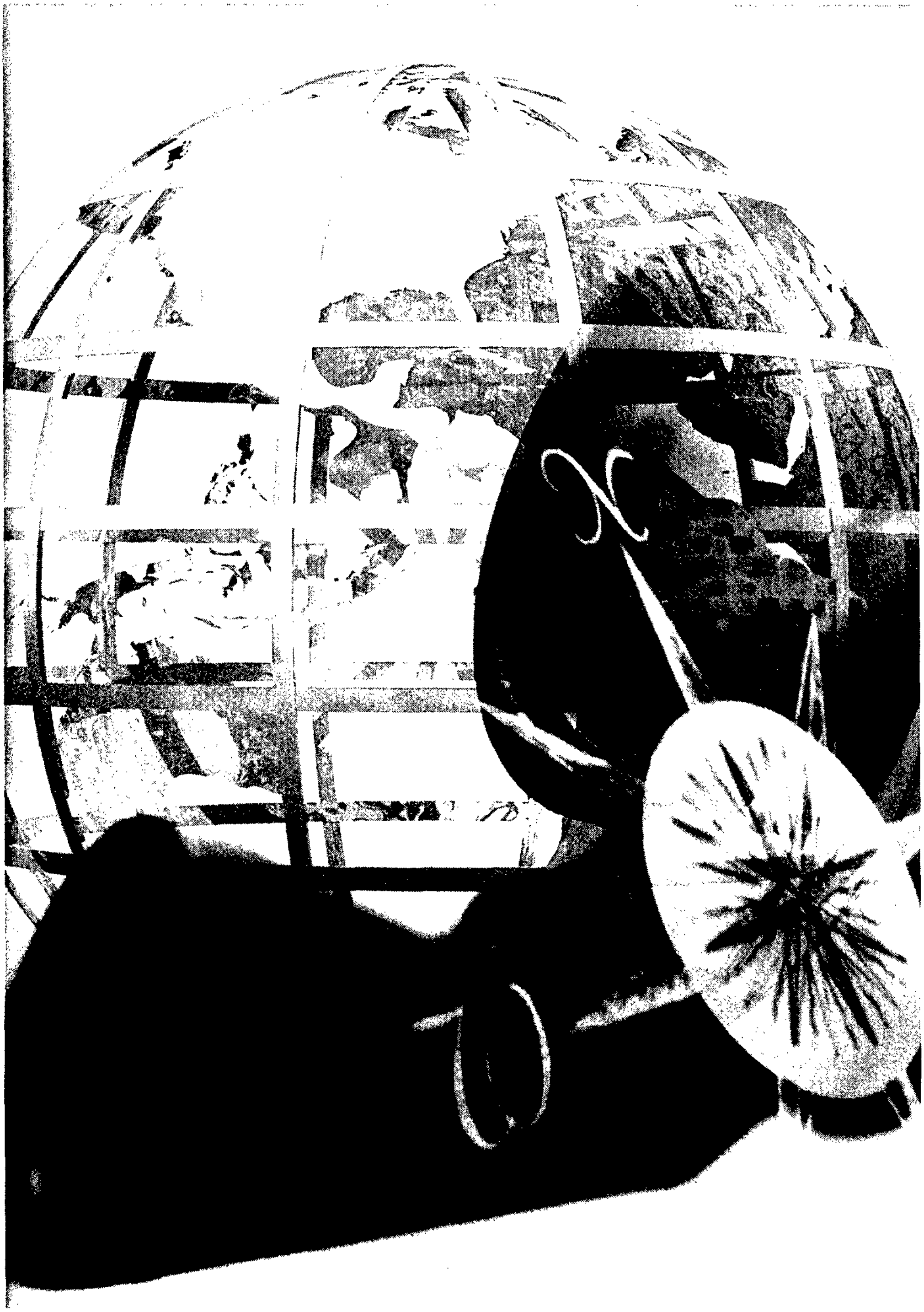

INVESTIGATING THE INTEGRATION OF ACQUIRED FIRMS IN HIGH-TECHNOLOGY INDUSTRIES: *IMPLICATIONS FOR INDUSTRIAL POLICY*

Maj David R. King, USAF and Lt Col John D. Driessnack, USAF

Acquisition activity persists despite evidence that acquisitions do not improve firm performance. Further, government policy toward the defense industry has advocated consolidation in the name of nominal cost savings. We explore the role acquisitions play toward technology transfer and begin to identify factors associated with acquisition success through a review of existing research on post-acquisition performance that primarily considers acquiring firm stock performance. Using this research as a foundation, we build a model to analyze post-acquisition performance using a sample of high-technology firms. Results suggest critical success factors associated with post-acquistion stock performance are poorly understood. We conclude that proactive government policy toward high-technology industry mergers and acquisitions may be misguided due to difficulty in predicting acquisition outcomes.

Merger and acquisition activity involves discrete events associated with a high tempo of change that modify the competitive dynamics of affected industries. Merged firms combine additional resources and capacity that can threaten the market position and profitability of remaining firms. The implications of using acquisitions to alter competition in industry may carry higher stakes in high-technology industries, because high-technology firms are an important source of U.S. economic competitiveness and are key components of the defense industrial base.

The Department of Defense (DoD) encouraged merger and acquisition (M&A) activity after then Deputy Sec-

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retary of Defense William Perry told defense industry executives that declining defense spending required consolidation. The 1993 meeting became known as the "Last Supper" and in the next four years the value of defense mergers was eight times the level of the preceding four years (Augustine, 1997). In a controversial program that became to be known as *payoffs for layoffs*, the DoD, in an effort to help realize expected cost savings, reimbursed defense firms for the cost of merging. The program, to date, has resulted in $4.77 billion in DoD savings with a corresponding cost of $869 million (Department of Defense [DoD], 2002), or approximately one percent of the 2003 defense budget.

"Acquiring technology is often the motivation for acquiring another firm."

Firms pursue acquisitions to increase performance (Finkelstein, 1997); however, research findings on the impact of an acquisition on acquiring firm performance remains inconclusive (e.g., Haspeslagh & Jemison, 1991; Sirower, 1997). Given the high level and dollar of acquisition activity, research needs to identify factors associated with acquisition success. The goal of the current paper is to begin to answer the following policy questions:

1. Does technology transfer occur when high-technology firms are acquired?

2. Is it reasonable to anticipate investor benefits from defense industry consolidation?

TECHNOLOGY AS A MOTIVATION FOR ACQUISITIONS

Acquiring technology is often the motivation for acquiring another firm. In reviewing the different perspectives toward acquiring technology, two conflicting perspectives dominate. Researchers tend to either view external technology as a substitute for Barkema and Vermeulen (1998) Bower (2001) or a complement to Cohen and Levinthal (1989, 1990) internal innovation. Either view has implications for technology transfer.

In the current sample[1], the average research and development (R&D) intensity for acquiring firms was significantly below the average for firms in their industry ($p < .001$), suggesting that firms use acquisitions as a substitute for R&D or that acquired technology is used as a substitute for internal innovation.

However, acquirers still perform R&D and it may provide a facilitating role to acquiring external technology. This idea relates to the concept of *absorptive capacity*, or the ability of a firm to recognize, assimilate, and convert new information to commercial ends, that is built up through R&D investment (Cohen & Levinthal, 1989, 1990). If firms acquire high-technology firms for the express purpose of assimilating a target firm's technology, there are clear implications for the acquisition of U.S. companies by foreign firms.

For example, *ASM Lithography Holding NV*, a Dutch company, and its May 2001 acquisition of *Silicon Valley Group* (SVG) Inc. was delayed, because of national-security issues with a SVG subsidiary, *Tinsley*, which makes lens polishing technology for chip equipment, satellites, and missile guidance systems (Clark & Simpson, 2001). However, the acquisition was later approved and completed in May 2001 with the caveat ASM Lithography try to divest Tinsley over a six month period (Simpson, 2001).[2]

Without national security issues the acquisition of SVG would have been approved, because the Exon-Florio foreign acquisition law does not allow for consideration of economic issues (Simpson, 2001). Foreign firms accounted for approximately five percent of the acquisitions of U.S. high-technology firms between 1994 and 1997, and this may be an area for expanding anti-trust policy. The impact of the technology transferred on U.S. economic competitiveness is unknown, and represents an opportunity for additional research.

Factors Commonly Associated with Acquisition Success

Similar to previous studies, the current sample of acquisitions, on average, did not lead to abnormal returns for acquiring firms. However, some acquisitions performed better than others, so what factors are associated with acquisition success? A literature review of 46 empirical studies of post-acquisition performance published since Jensen and Ruback's (1983) review identified little overlap in the studies that researchers considered important in explaining post-acquisition performance.[3] We include the most commonly studied variables in our analysis to avoid statistical artifacts from missing variables. The logic behind the most commonly studied variables, the generally anticipated impact of each variable on post-acquisition performance, and their significance in the current study are shown in Table 1. The following sections further discuss this material.

Diversification

The impact of firm diversification on subsequent performance has received the most attention of researchers with some measure of relatedness considered in 30 of the 46 studies. Diversification involves whether a firm acquires another firm in its same industry, a related acquisition, or a firm in a different industry. Although no relationship between acquiring a related versus an unrelated firm and post-acquisition performance has been found in some studies (e.g., Fowler & Schmidt, 1989), the preponderance of literature suggests acquiring related firms leads to increased post-acquisition performance (e.g., Kusewitt, 1985).

Current results are consistent with existing research in that the acquisition of related targets leads to higher post-acquisition performance ($p < .05$; one-tail). However, the observed relationship is relatively weak with the degree that a target firm relates to an acquirer only explaining 2.1 percent of subsequent stock market performance. Still, the results support viewing technological progress as largely path dependent with the implication that acquiring firms are more likely to search and find value in target firms in areas related to their existing technological capabilities. The possiblity of increased performance may depend on a firm staying in a related industry.

> **"Diversification involves whether a firm acquires another firm in its same industry, a related acquisition, or a firm in a different industry."**

Table 1. Common Post-Acquisition Performance Research Variables

Variable	Anticipated Impact on Performance	Current Findings [a]
Diversification	Diversification (e.g., acquiring firms in non-related industries) is expected to have a negative impact on performance (see Berger & Ofek, 1995).	Expected impact is supported ($p < .05$) and explains 2.1% of the variance in performance.
Relative Size of Firms	The acquisition of smaller firms, in comparison to the acquiring firm, is expected to be easier and result in higher performance (see Kusewitt,1985).	Expected impact is supported ($p < .01$) and explains 7.2% of the variance in performance.
Acquisition Experience	Acquisition experience is generally considered to positively impact performance (see Hitt, Harrison, & Ireland, 2001).	Expected impact is not supported ($p = .22$).
Method of Accounting	Purchase accounting is generally considered to have a positive impact on performance (see Ravenscraft & Scherer, 1987).	Expected impact is not supported ($p = .15$).
R&D Expenditures	R&D expenditures should improve post-acquisition performance (see Cohen & Levinthal, 1989, 1990).	Expected impact is not supported ($p = .41$).
Friendliness of Acquisition	Friendly acquisitions are expected to lead to higher performance (see Kusewitt, 1985).	Not examined due to an insufficient occurrence of hostile high-technology acquisitions.
Debt Level	Firms with lower debt levels are more likely to experience higher performance (see Haspeslagh & Jemison, 1991).	Expected impact is supported ($p < .05$), and explains 3.0% of the variance in performance.
Form of Acquisition	Tender offers, in contrast to mergers, lead to higher performance (see Berkovitch & Khanna, 1991).	Expected impact is supported ($p < .10$), and explains 1.8% of the variance in performance.
Target Firm Performance	There are conflicting perspectives on how target firm performance will impact an acquiring firm's post-acquisition performance. Researchers support viewing post-acquisition performance as independent of target firm performance (Anand & Singh, 1997), distressed targets leading to higher performance (Bruton, Oviatt, & White, 1994), or profitable targets leading to higher performance (Mahoney & Pandian, 1992).	Current results suggest that acquiring firm profitability is not related to post-acquisition performance ($p = .15$).

[a] One-tail tests of significance.

In constrast to this finding, defense firms that are prime contractors have tended to make acquisitions that both consolidate specific industries (e.g., aircraft and Lockheed's purchase of General Dynamic's aerospace unit) as well as across industries (e.g., aircraft and ships with Northrop Grumman's purchase of Newport News Shipbuilding). However, defense firms appear to have generally chosen to focus on acquiring other firms in defense industry and not expanding into commerical markets. It is possible that the specialization of defense firms in relating to their unique customer, the government, provides them an advantage that does not correspond to traditional industry boundaries.

Relative Size of Firms

The ability of an acquiring firm to assimilate a target firm may be impacted by their relative size simply because it is easier for a larger firm to integrate resources from a smaller firm. Kitching (1967) found that unsuccessful acquisitions correlated strongly between firms of similar size. Acquisition risk may be reduced if the target firm is large enough to achieve 'critical mass' while remaining smaller than the acquiring firm (Kusewitt, 1985), due to decreased financial strain and integrative effort. Existing research suggests that, in general, acquisitions of smaller firms by larger firms should lead to higher performance.

Current results indicate that larger targets correlate with higher stock gains ($p < .01$; one tail) and explain 7.2 percent of the observed variance in post-acquisition performance. However, over 98 percent of the targets were still smaller than the acquiring firm. This result appears to confirm previous research that acquisition risk is reduced when a target is smaller than an acquiring firm, but large enough to demand enough management attention to ensure proper integration. For acquisitions involving large, prime defense contractors, targets from this point forward will most likely be smaller than the prime defense contractors. This suggests a potential post-acquisition performance advantage for prime contractors in the defense industry.

Acquisition Experience

Experience from past acquisitions, at the organizational level, may build facilitating processes for the identification and integration of target firm resources that may be required to improve post-acquisition performance (Haspeslagh & Jemison, 1991). However, consistent findings on the relationship between acquisition experience and post-acquisition performance do not exist. Still, Hitt, Harrison, and Ireland (2001) caution "the importance of the link between managerial experience and M&A success should not be underestimated (p. 55)." Current results suggest that either high-technology acquisitions are unique with acquisition experience not predicting post-acquisition performance ($p = .22$; one tail). Alternatively, this result may imply that firms *could* benefit from acquisition experience, and that managers simply treat acquisitions as unique events.

"...Defense firms appear to have generally chosen to focus on acquiring other firms in defense industry and not expanding into commerical markets."

Method of Accounting

Few studies control for accounting method, even though it has been shown to impact firm performance measures (Ravenscraft & Scherer, 1987). Historically, there have been two methods of accounting for an acquisition — pooling of interests or purchase.[4] Under pooling of interests, assets of an acquired firm are recorded at their pre-merger book value and the difference in amount paid for a firm is either debited or credited to acquirer's stockholders equity account. Under purchase accounting, acquired assets are entered at the effective price paid. Pooling of interest accounting is significantly associated with higher acquisition premiums (Ravenscraft & Scherer, 1987) and the premium paid negatively impacts post-acquisition performance (Sirower, 1997). Current results suggest that method of accounting does not impact post-acquisition performance (p = .15; one-tail).

"Friendly acquisitions involve transactions where an acquiring firm's overtures are not resisted by a target firm's top management."

R&D Expenditure

Research suggests that increased technological capability enables firms to be aware of the significance of new external technology (Berry & Taggart, 1998). Nelson and Winter (1978) argue that the capacity to recognize and exploit technological opportunities is a function of a firm's technology resource commitments, such as R&D investments, and that firms that track the progress of technology tend to prosper. R&D investments build internal technological capabilities that help firms adapt to changing markets (Zahra & Covin, 1993). Additionally, more R&D intensive firms should be more proactive in exploiting external opportunities (Cohen & Levinthal, 1990). However, current results suggest that there may be diminishing returns to performing R&D beyond some threshold level. In other words, firms may only need to perform enough R&D to remain aware of external technology and maintain the ability to absorb needed technological developments.

Friendliness of Acquisitions

Friendly acquisitions involve transactions where an acquiring firm's overtures are not resisted by a target firm's top management. Theory suggests friendly acquisition should lead to higher performance. For example, Kusewitt (1985) simply stated: "unfriendly takeovers should be avoided (p. 166)." Consequently, hostile acquisitions are relatively infrequent with only 172 hostile acquisitions out of over 35,000 completed between 1976 and 1990 (Jensen, 1993). Therefore, whether an acquisition was friendly is not included in the current analysis, due to a lack of observed hostile acquisitions.

Debt Level

The debt of an acquiring firm may impact post-acquisition performance. Unused debt capacity can be regarded as a firm resource (Haspeslagh & Jemison, 1991), and if an acquiring firm cannot afford the price demanded by a target, the anticipated synergies in a combined company cannot be achieved. Additionally, higher debt levels may lead to more strict financial controls that can decrease performance (Hitt, Hoskisson, Johnson, & Moesel, 1996). Present results suggest that firms with less debt experience higher subsequent performance ($p < .05$; one tail) with debt explaining three percent of the variance in an acquiring firm's post-acquisition performance. It appears that increased debt levels represent an additional burden for acquiring firms seeking increased performance. This represents a challenge for most defense firms since they carry relatively large levels of debt and poor credit ratings (Defense Science Board, 2000).

Form of Acquisition

The *form of an acquisition* involves the nature of the offer made by an acquiring firm with the primary choices involving either a tender offer or a merger Berkovitch & Khanna, 1991). *Tender offers*, or proposals made directly to a target firm's shareholders, are made through public bids, while *mergers*, or negotiations directly with a target firm's managers, are generally initiated under a veil of secrecy. Existing research has found that tender offers significantly outperform mergers (Rau & Vermealen, 1998). Berkovitch and Khanna (1991) propose that the difference in performance results from differences in the amount of information made public during a tender offer versus a merger, where the greater information disclosure in tender offers leads increased synergy. The basis of Berkovitch and Khanna's (1991) argument is that tender offers lead to greater competition for a target firm. However, an alternate explanation relevant to the acquisition of technology resources is that the increased information disclosure of tender offers decreases the amount of uncertainty target firm employees' experience.

Acquisitions create uncertainty for employees in target firms leading to a tendency toward self-preservation that inhibits its transfer of capabilities and resources (Haspeslagh & Jemison, 1991). Employee resistance to integration is particularly relevant in the assimilation of the technology resources because the implicit expertise of R&D personnel is far more valuable than the technology they have developed (Bower, 2001).

"It appears that increased debt levels represent an additional burden for acquiring firms seeking increased performance."

Whatever the ultimate reason, acquisitions completed through a tender offer are expected to be positively related to post-acquisition performance. Current results suggest that tender offers do lead to higher post-acquisition performance ($p < .10$; one tail) with form of acquisition explaining 1.8 percent of the variance in post-acquisition performance. This result supports either tender offers resulting in increased competition or information disclosure leads to increased post-acquisition performance.

Target Firm Performance

It seems reasonable that would-be acquirers will evaluate the attractiveness of a target firm's resources in light of the firm's performance. However, consistent guidance on the expected relationship does not exist. There are at least three possible relationships between target firm performance and an acquiring firm's post-acquisition performance.

First, acquiring firm's may view target firm profitability as a signal of the value attached to its technological resources by would-be acquirers. Specifically, it is possible that would-be acquirers will interpret positive profitability as the market's independent verification that the target firm possesses valuable resources. High profits signal uncertain imitability and the more firm specific or rare a firm's resources, the more likely the firm will earn above normal rates of return (Mahoney & Pandian, 1992). Therefore, higher post-acquisition performance may result from acquiring target firms that possess valuable resource combinations indicated by higher profitability.

The second possibility is that, consistent with Bruton, Oviatt, and White's (1994) observations, acquirers are particularly attracted to distressed firms with resources of known or potential value to the acquirer. The assumption here is that the target firm's poor financial performance is a reflection of either resource mismanagement or the absence of complementary resources needed to create competitive advantage. Thus, the acquisition of a poorly performing firm may be attractive if the acquiring firm assumes it can improve the management of the target firm's resources or successfully combine them with its own, pre-existing internal resources.

"...acquiring firms consider both distressed and highly profitable firms as potential acquisition candidates."

Third, it may be that target firm profitability has no impact on an acquiring firm's post-acquisition performance. Anand and Singh (1997) suggest that the benefit of transferring firm resources in an acquisition is independent of the acquired firm's prior performance. Therefore, in their opinion, acquiring firms should seek targets with resources they need without considering the profitability of the firms employing those resources. Current results indicate that target firm profitability in the year prior to an acquisition is not related to post-acquisition performance by an acquiring firm ($p = .15$; one tail). This implies that acquiring firms consider both distressed and highly profitable firms as potential acquisition candidates.

Impact of External Forces on Acquisition Performance

The vast majority of acquisition research and the variables discussed so far only consider the impact of variables linked to factors internal to firms that can be directly observed and to some extent controlled. However, it is also reasonable that post-acquisition performance depends on factors external to firms.

We consider two characteristics that may influence post-acquisition performance. First, an acquiring firm's environment is important because it sets the competitive context, and rivalry over scarce environmental resources and opportunities should influence firm actions and subsequent performance. Industry characteristics can influence the performance of firms (Porter, 1985). Further, Bergh (1998) found the benefits of external technology were moderated by a firm's environment. Second, the timing of an acquisition may impact an acquiring firm's post-acquisition performance.

Table 2. External Forces Influencing Post-Acquisition Performance

Variable	Anticipated Impact on Performance	Current Findings [a]
Firm Environment	Firms operating in more attractive environments should experience higher performance (see Dess & Beard, 1984).	
	1. Acquiring firms operating in munificent environments are more likely to experience higher performance.	1. Munificence does not impact post-acquisition performance ($p = .28$).
	2. Acquiring firms operating in less dynamic environments are more likely to experience higher performance.	2. Dynamism does not impact post-acquisition performance ($p = .42$).
	3. Acquiring firms operating in less complex environments are more likely to experience higher performance.	3. Complexity is significant ($p < .05$) and explains 2.4 % of post-acquisition performance.
Timing of Acquisition	Early acquisitions should outperform later acquisitions.	Mixed support, but the year an acquisition was completed explained 4.7 % of post-acquisition performance.

[a] One-tail tests of significance

The impact of variables related to both external factors on subsequent post-acquisition performance is summarized in Table 2. The following sections further discuss these relationships.

FIRM ENVIRONMENT

Research supports viewing a firm's environment as a multidimensional construct with three dimensions — munificence, dynamism, and complexity (e.g., Dess & Beard, 1984). Although the labels applied to the different dimensions vary, there is an underlying commonality in the underlying concepts. For the purposes of the present research, the effects of industry are controlled by computing firm measures relative to their four-digit Standard Industrial Classification (SIC) code using the procedures described by Keats and Hitt (1988).

Munificence relates to the scarceness of environment resources that support firm growth in a given industry (Dess & Beard, 1984). This environmental dimension has been discussed within the population ecology literature under the label of environmental carrying capacity (Aldrich, 1979). Munificence is characteristically assumed to have a positive impact on firm performance and is calculated from changes in an industry's net sales and operating income during the preceding five-year period.

Current results find that munificence is not significant (p = .28; one tail) in explaining an acquiring firm's post-acquisition performance. From the perspective of the 1990's defense industry consolidation, this means that post-acquisition performance may be independent of whether an acquiring firm's industry is contracting. From the perspective of 1990's defense industry consolidation, defense firms should have been able to adjust operations to sustain performance in face of DoD spending that in 2001 dollars declined nearly 18 percent for R&D and 56 percent for procurement between 1987 and 2000 (DoD, 2000).

"In an environment with fewer competitors, rivalry often plays a coordinating role that imposes competitive discipline on an industry."

Dynamism corresponds to uncertainty or the degree of instability and unpredictable change in an industry (Dess & Beard, 1984). Environmental change itself does not imply dynamism, instead dynamism exists when change cannot be anticipated and adequately predicted, creating a situation where integration and coordination are more difficult. Williamson (1975) suggests that under increasing environmental uncertainty higher quality information could be gained by managing transactions internally (i.e., making an acquisition). Current results suggest that industry volatility in and of itself does not impact post-acquisition performance (p = .42; one tail). One intrepretation of this result is that firms adopt acquisition activity as a tool to adapt to environmental change that helps firms ensure their continued survival. This is particularily relevant to the defense industry consolidation witnessed during the 1990s.[5]

Complexity relates to the number and diversity of other organizations a firm must interact with (Dess & Beard, 1984). Complexity is reflected in such factors as the breadth and variety of a firm's geographic markets, customers, suppliers, and competitors. In general, fragmented industries are regarded as more complex than concentrated industries (Keats & Hitt, 1988). In an environment with fewer competitors, rivalry often plays a coordinating role that imposes competitive discipline on an industry (Keats & Hitt, 1988). In contrast, market power and resources are relatively widely and evenly distributed among numerous firms in fragmented industries, creating heterogeneous conditions involving intense rivalry. Thus, the dynamics of industry concentration may impact the motivation and resulting performance resulting from absorbing recognized external technological capabilities.

Current results indicate that less complex (i.e., more concentrated industries) lead to higher post-acquisition performance ($p < .05$; one tail). At first glance, this result suggests that continued consolidation of the defense industry may be a mistake in that further consolidation, at this point, would result in two or fewer prime contractors for primary weapon system platforms (e.g., ships, aircraft, tanks, satellites, missiles, etc.). Typically this situation would raise concerns about the ability of industry to retain either enough competition or sustain innovation. However, any monopolistic power in defense firms is compensated by their facing a monopsony, or market with only having a single customer (e.g., the DoD). Additionally, the government audits the cost of defense contracts and limits the profit defense firms can earn from them.

It is unclear whether continued consolidation in the defense industry and any anti-competitive impacts should be a concern. Still, whether additional consolidation of defense firms occurs or not, rationalization of production capacity should be considered. Despite industry consolidation at the end of the 1990s, every one of the eight military aircraft lines and five military helicopter lines open at the end of the Cold War were still in production (Sapolsky & Gholz, 1999). To a large extent, the facilities responsible for producing 5, 195 F-4 Phantom II aircraft (Boeing, 2002) and other Cold War era weapons continue to be maintained. Not even the most optimistic projections predict the same number of models or quantities of future aircraft will be produced due largely to improvements in capability[6] and increased emphasis on jointness.

Timing of Acquisition

One possible explanation of an acquiring firm's post-acquisition performance consistent with population ecology (Aldrich, 1979) is that early acquisitions should outperform later acquisitions. An acquisition represents an entry decision for an acquiring firm that may involve "selection" of firms with better resources (Anand & Singh, 1997). Therefore, early acquirers may be able to "select" the best targets and later acquirers have a decreased and less desirable pool of targets to select from. Although the timing of an acquisition has been previously found to be significant (Fowler & Schmidt, 1988), few studies include time as an explanatory power and only Shelton (1988), in a study of the impact of changing antitrust regulations, attempts to explain time differences in acquisition performance.

Current results suggest that the timing of an acquisition is significant ($p < .10$) in explaining an acquiring firm's performance. Based on one-tail significance tests, acquisitions completed in 1995 ($p < .10$) and 1996 ($p < .05$) performed significantly worse than the 1994 reference category. However, the performance of acquisitions completed in 1997 is not significantly different from acquisitions completed in 1994. The results would appear to show mixed support for early acquisitions outperforming later acquisitions. However, the nature of the cross-sectional regression employed assumes that the underlying pool of firms does not change. There is significant turnover in high-technology industries with firms both entering and exiting the market. The non-significant difference between 1994 and 1997 may have resulted from the ability of acquiring firms to select from a relatively diverse pool of targets in both years. Further studying the impact of acquisition timing on performance represents an opportunity for future research.

"It is unclear whether continued consolidation in the defense industry and any anti-competitive impacts should be a concern."

Conclusion

In regard to the first research question, there is clear evidence that firms use acquisitions as a tool to gain access to technology. This finding has implications for acquisitions of U.S. technology firms by foreign firms. Only national security and not economic security reasons provide grounds for disapproving an acquisition by a foreign firm under the Exon-Florio foreign acquisition law. It is reported that the DoD is considering cross-Atlantic defense industry consolidation (Urwitz, 1999). Based on the potential technology transfer implications and the demonstrated difficulty in predicting post-acquisition outcomes, encouraging cross-Atlantic defense industry consolidation to realize cost savings may be misguided.

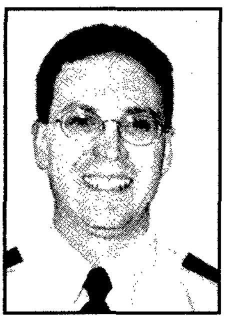
In regard to the second research question, acquisitions, on average, do not improve acquiring firm stock performance. Completed analysis indicates that several factors are correlated with higher post-acquisition stock performance. However, only four of the factors commonly associated with acquisition performance that are under the control of mangers appear to impact post-acquisition stock performance. First, the acquisition of target firms in related industries appears to improve post-acquisition performance. Second, the acquisition of targets that remain smaller than an acquiring firm, but are still of a sufficient size, leads to higher post-acquisition performance. Third, acquiring firms that carry lower debt levels are more likely to experience higher post-acquisition performance. Fourth, acquisitions completed using tender offers lead to higher performance. Combined, these four factors explain only 12 percent of the observed variance in post-acquisition performance. This is consistent with existing acquisition research that in general explains "less than 10 percent" of the variance in the stock performance of acquiring firms (Sirower, 1997, p. 158). Clearly the dollar value and volume of acquisition activity requires a better understanding of this phenomenon. Therefore, we also considered the impact of external factors on post-acquisition stock performance.

"In regard to defense industry consolidation, results indicate it is not reasonable to expect consolidation will achieve significant benefits in firm stock performance."

External factors relating to an acquiring firm's industry munificence and timing of an acquisition explain 7.1 percent of the variance in post-acquisition stock performance. Stated differently, 37.2 percent of the explained variance in the current study is due to external factors that are beyond direct control and the majority of variance still remains unexplained after including the most common factors in M&A research in our model. In total, this study only explains 19.1 percent ($F = 2.12$; $p = .015$) of the variance in post-acquisition performance. This means that the majority of variance in post-acquisition stock performance remains unexplained and suggests that government policy aimed at influencing high-technology M&A activity may be misguided since any government intervention may have opposite the desired effect. Additionally, antitrust policies in high-technology industries may be less relevant because the high rate of technology change may keep firms from establishing and exercising monopoly powers.

In regard to defense industry consolidation, results indicate it is not reasonable to expect consolidation will achieve significant benefits in firm stock performance. Although considerations of defense industry stock performance may be secondary to the governments interests in the short-term, it is of concern in the long-term because it impacts the attractiveness of the industry to employees and investors. The long-term success and health of the defense industry requires attracting the best employees (Defense Science Board, 2000) and maintaining the ability of defense firms to utilize the capital markets. However, a significant portion of high-technology firm employees comes from stock options, and poor performing defense firms would be less able to attract and retain the best engineers. Considering additional performance measures for the defense industry represents an opportunity for future research.

In closing, the present research reviews current post-acquisition stock performance literature to test factors impacting the post-acquisition stock performance of firms that acquire high-technology targets. Results of the study show that internal and extenal factors do not provide a clear guidance for managers or government policy makers. Additional research, especially focused on the defense industry and its unique market, is needed if factors are to be found that can be used to influence industrial policy.



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APPENDIX: RESEARCH METHODOLOGY

This appendix describes in detail the research methodology used beginning with the sample. The discussion of the sample is followed by a description of the operationalization of all variables and their data sources. Finally, the statistical procedure is summarized.

SAMPLE

The sample used for this study focused on public, high-technology firms that were acquired between January 1, 1994 and December 31, 1997 and had a market capitalization of at least $10 million. This focus enabled us to isolate acquisitions of a specific type and to avoid studying a cross-section of merger and acquisition (M&A) activity that may introduce extraneous effects. Additionally, the time frame offered control over known impacts of the business cycle on acquisition activity (Ramanujam & Varadarajan, 1989) by ensuring all measurement was limited to a period of favorable economic conditions. A $10 million market capitalization restriction is consistent with the lower bound observed in previous acquisition research (e.g., Finkelstein, 1997; Ravenscraft & Scherer, 1987) and was intended to ensure target firms were large enough to impact acquiring firm performance.

High-technology target firms were identified as those that (1) were in two-digit Standard Industrial Classification (SIC) code industries commonly recognized as high-technology, and (2) displayed moderate research and development (R&D) intensity prior to being acquired. Existing literature commonly recognizes seven two-digit industry sectors as high-technology industries: Chemicals [28], Computer Equipment [35], Electronics [36], the aerospace industry [Transportation: 37], Instruments [38], Communications [48], and the software industry [Business Services: 73] (e.g., Certo, Daily, & Dalton, 2001). Moderate R&D intensity was operationally defined as R&D-to-Sales of two percent or greater. This value was based on rounding up from what has been reported as the overall industry average R&D-to-Sales figure of 1.5 percent (e.g., Ravenscraft & Scherer, 1987). This enabled us to conservatively and objectively identify target firms as reasonably R&D intensive without unduly restricting the sample. After applying these screens, a census of 312 high-technology firms was identified.

To identify the final sample, however, two additional restrictions were applied. First, acquisitions were eliminated if the target and acquiring firms' SIC codes were not identified by COMPUSTAT to the four-digit SIC level. This controlled for industry effects and allowed the use of a categorical entropy diversification measure for firm relatedness. It also offered the benefit of controlling for potential confounding effects of conglomerate firms. Second, acquiring firms had to be available in the Center for Research on Security Prices (CRSP) database to allow us to calculate several of our measures (e.g., Jensen's alpha, the premium paid, and relative size). The final sample includes 133 firm pairs.

Measures

This section explains the operationalization for each variable beginning with the dependent stock performance variable, and then the explanatory variables in the order they are discussed in the paper.

Firm Performance. Jensen's alpha (Alexander & Francis, 1986), a variation of the two-parameter market model, was used to measure an acquiring firm's performance. For each month after an acquisition (t = 1 to 36), the regression model shown in Figure 1 was calculated.

As the regression intercept, Jensen's alpha measures the average difference between the market benchmark's return and the return of the firm (Alexander & Francis, 1986), or abnormal return. If Jensen's alpha is not significantly different from zero, then a firm's stock performance is the same as the market benchmark. Once calculated for each firm, Jensen's alpha is used as the dependent variable in a cross-sectional analysis to test independent variable effects. This application of cross-sectional analysis allows the association between an event and abnormal returns to be observed (Campbell, Lo, & MacKinlay, 1997). Individual firm stock and market benchmark monthly rates of return were collected from the CRSP database with the S&P500® index serving as the market benchmark.

Diversification. The relatedness of an acquisition was measured as a categorical entropy measure (Hoskisson, Hitt, Johnson, & Moesel, 1993) where relatedness varies based on the degree that target and acquiring firm primary four-digit SIC codes match. An unrelated acquisition (value = 0) is defined as the acquisition of a target firm in a four-digit SIC outside an acquiring firm's two-digit industry group. The first level of related acquisitions occurs when an acquiring and target firms two-digit industry groups match (value = 1). Similarly, when an acquiring and target firms SIC code matches to three- and four-digits relatedness, values of two and three will be assigned respectively.

Relative size. The relative size of firms was calculated similar to Sirower (1997) as the ratio of target firm market

$$R_{it} = \alpha_i + \beta_i (R_{mt}) + \varepsilon_{it}$$

where:

R_{it} is the monthly rate of return of firm i during month t

α_i is Jensen's alpha for firm i

β_i is a firm i's stock price variance relative to the variance of the market benchmark (m)

R_{mt} is the monthly rate of return of the market benchmark (m) during month t

ε_{it} is the random error term

Figure 1. Regression Model

capitalization divided by acquiring firm market capitalization. Market capitalization was calculated from either the CRSP or Security Data Corporation (SDC) database four weeks prior to an acquisition announcement.

Acquisition Experience. Acquisition experience was operationalized similar to Hayward (2002) with an acquiring firm's acquisition experience recorded as the sum of a firm's acquisitions for the previous three years. Acquisition experience was measured prior high-technology acquisition experience of an acquirer in the three years prior to the acquisition of interest.

Method of Accounting. The method of accounting for an acquisition was measured by using a dichotomous dummy variable (pooling = 0 and purchase = 1). Information on method of accounting was identified from either the SDC database or an online search of business press.

R&D Expenditures. An acquirer's R&D expenditures were measured using R&D intensity (Cohen & Levinthal, 1989, 1990) minus the average R&D intensity of firms in its industry to control for industry effects (Dess, Ireland, & Hitt, 1990). The resulting relative R&D intensity measure was averaged for the prior three years to represent a firm's level of commitment to developing technological capability, while controlling for annual variation. Firm and industry R&D intensity were calculated using data available from *COMPUSTAT*: R&D expenditures (data code 46) divided by sales (data code 12). Industry R&D intensity was calculated from *COMPUSTAT* by calculating the average R&D intensity for all firms with the same four-digit SIC code.

Acquiring Firm Debt. The level of an acquiring firm's debt was measured using the current ratio. It was calculated by dividing a firm's current assets by its current liabilities with data from *COMPUSTAT* — data codes 4 and 5 respectively.

Form of Acquisition. The form of acquisition, merger or tender offer, was measured using a dichotomous dummy variable (merger = 0 and tender offer = 1). Information on the form of an acquisition was identified from either the SDC database or an online search of popular business press.

Target Firm Performance. The industry adjusted profitability of a target firm was measured by calculating a target firm's Return-on-Sales (ROS) in the year prior to its being acquired. Profitability was measured using ROS for each firm the year prior to an acquisition, and was obtained from *COMPUSTAT*: net income (data code 172) divided by sales (data code 12).

Firm Environment. A firm's environment was measured using the three environmental dimensions of munificence, dynamism, and concentration computed at the four-digit SIC level using the procedure described by Keats and Hitt (1988) and calculated for the five preceding years, beginning in the year prior to acquisition. Succinctly, munificence is the average of the regression coefficients of a four-digit industry's net sales and operating income over the preceding five-year period. Dynamism is the average of the standard errors of the regression slopes for the two munificence regression equations. Complexity is a market concentration measure computed by regressing the terminal-year (i.e., year five) market shares of the firms in a given industry on these firms' initial-year (i.e., year one) market shares. Note: lower values on the complexity scale signify *higher* levels of complexity.

Timing of Acquisition. The year, or time impact, of an acquisition was measured using a polychotomous dummy variable (1995 = 1, 1996 = 2, and 1997 = 3) with the year 1994 serving as the reference category.

ANALYSIS

Analysis of Variance (ANOVA) was used to identify the significance and individual level of variance explained by independent variables (Bray & Maxwell, 1985). Supplemental analysis was used to determine if the assumptions (the same as regression) of analytical technique were met. Graphs of error terms were consistent with conclusions that the are normally distributed. Further, none of the variable bivariate correlations exceeded .5, indicating that multicollinearity should not be a concern (Gujarati, 1995, p. 335). The data from independent firms over different time periods were combined in a cross-sectional analysis, and would not be expected to exhibit autocorrelation commonly associated with time series data (see Griffiths, Hill, & Judge, 1993). However, the cross-sectional analysis of data over several years and the significant difference between the year an acquisition was made may indicate a violation of the constant variance assumption (see Griffiths, Hall, & Judge, 1993). Supplementary analysis using the Goldfeld-Quandt F-test showed none of the year-year and full model combinations are significant. This suggests that variance across the different years is homoskedastic, or displays constant variance.

ENDNOTES

1. Please see the Appendix for a description of the study's methodology.

2. The authors were unable to confirm that Tinsley was ever divested from ASM Lithography.

3. The potential implication is that existing M&A research may be biased by model under-specification (see Griffiths, Hill, & Judge, 1993: 312).

4. The Financial Accounting Standards Board eliminated pooling of interests accounting and modified recording of goodwill with purchase accounting for all acquisitions completed after July 1, 2001.

5. We would like to thank Steven L. Schooner of George Washington University Law School for making this observation.

6. A single F-117 mission can accomplish today what 95 sorties achieved during Vietnam or what 4,500 B-17 bombers achieved during WWII (Toffler & Toffler, 1993).

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DISTRIBUTION

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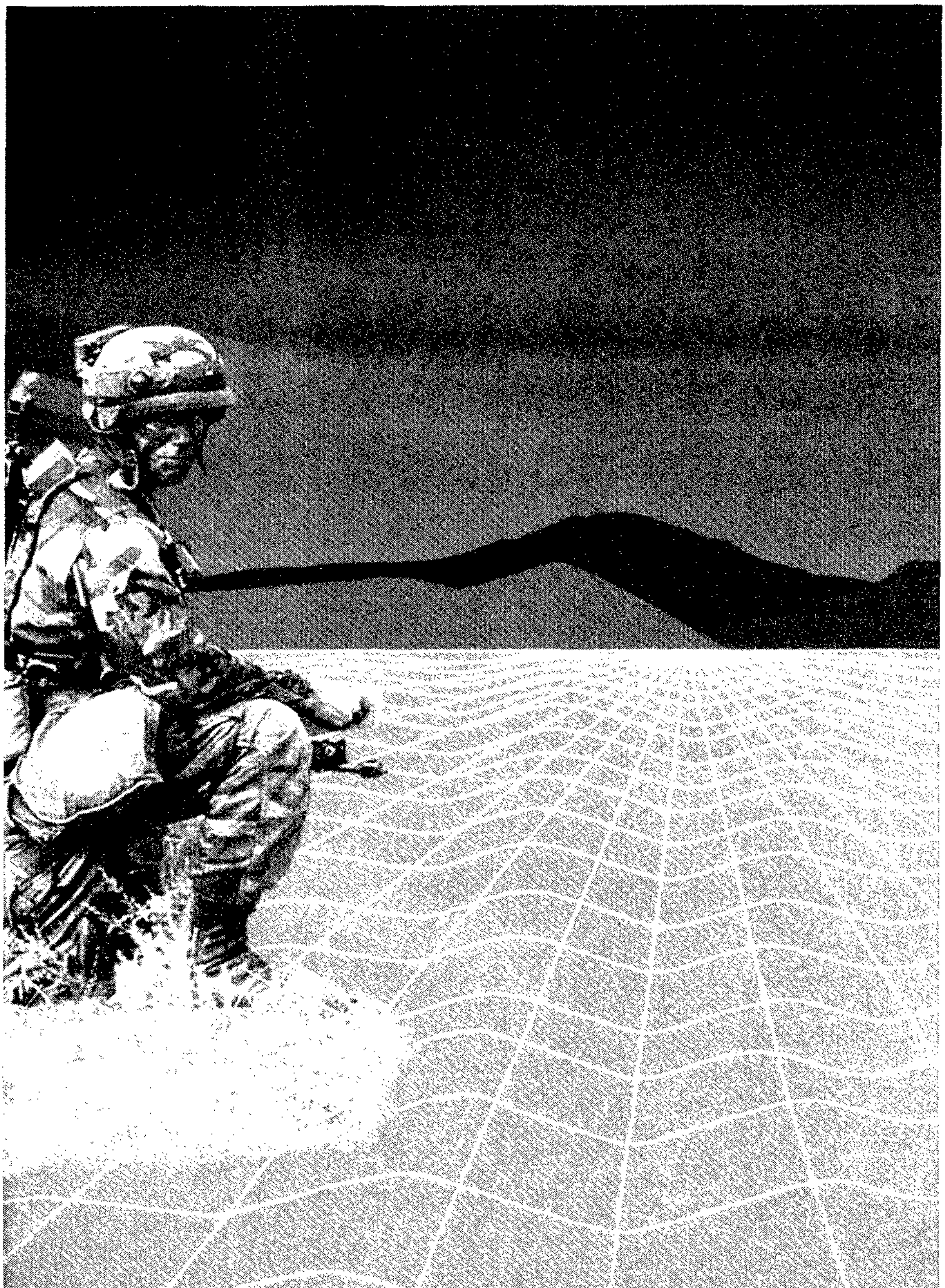


WHY THE "T" IN SMART
A CONSTRUCTIVE SYNERGY

LTC Michael D. Proctor, USA (Ret), Amy Posey-Macalintal, and Dennis Kulonda

Department of Defense (DoD) simulation-based acquisition (SBA) is widely discussed in literature. The Army offers a broad vision of SBA concept in the form of Simulation and Modeling for Acquisition, Requirements, and Training (SMART), accenting not only the Acquisition process but also essential contributions from the Requirements and Training communities. This research highlights how organizational training simulation has significantly helped the acquisition process beyond the confines of post-acquisition training.

Training is essential to the successful fielding of any new weapon system. As a part of the system life cycle, the value of training is well established. Further, the training community is well known for their ability to contribute to the development of training packages for new materiel acquisitions. This research reveals that with increased realism, training simulations may now provide a significant and credible resource useful to acquisition managers, which goes beyond training packages.

The research investigates the hypotheses that an organizational training simulation may support materiel acquisition and, likewise, materiel acquisition may support organizational training simulation development. Using a case study methodology, the research reveals how the Close Combat Tactical Trainer (CCTT) training simulation played a critical part in the Battlefield Combat Identification System (BCIS) acquisition as well as how the BCIS advanced the CCTT.

This paper presents archival record, experimentation, cost, interview, and survey highlights from the case study as well as discusses the Simulation and Modeling for Acquisition, Requirements, and Training (SMART) approach to acquisition. The SMART approach, in part, advocates an explicit strategy to integrate training simulation in acquisition where appropriate. Additionally, this paper also identifies tenets that may promote a synergistic and mutually beneficial relationship between training simulation and materiel acquisition. Finally, the case study identifies process mechanisms that may help insure up-to-date-training systems are available when new equipment systems are fielded or possibly tested.

EMPLOYING TRAINING SIMULATION IN THE ACQUISITION PROCESS

Simulation-based acquisition as pursued by Department of Defense (DoD) is widely discussed in literature and conference activities. The use of simulation in the system life cycle continues to grow. Managers report gains in terms of quality, productivity, and performance as well as reductions in cost, cycle time, lag time, and risk. This success has not come about by chance, but rather by planned and deliberate actions by astute acquisition managers. A few examples are referenced below (Zittel, 2001; Brantley, McFadden, & Davis, 2002; Garber, 2001; Johnson, McKeon, & Szanto, 1998; Sanders, 1997).

The Army and its simulation action agent, the Army Modeling and Simulation Office, promote a version of simulation-based acquisition called SMART (Ellis, Kern, & Hollis, 2002; Lunceford, 2002). SMART is more than semantics. SMART emphasizes not only the essential acquisition process, but also the quality enhancing contributions of the training and requirements communities to that process.

For the Army, a key vehicle for success has been the Simulation Support

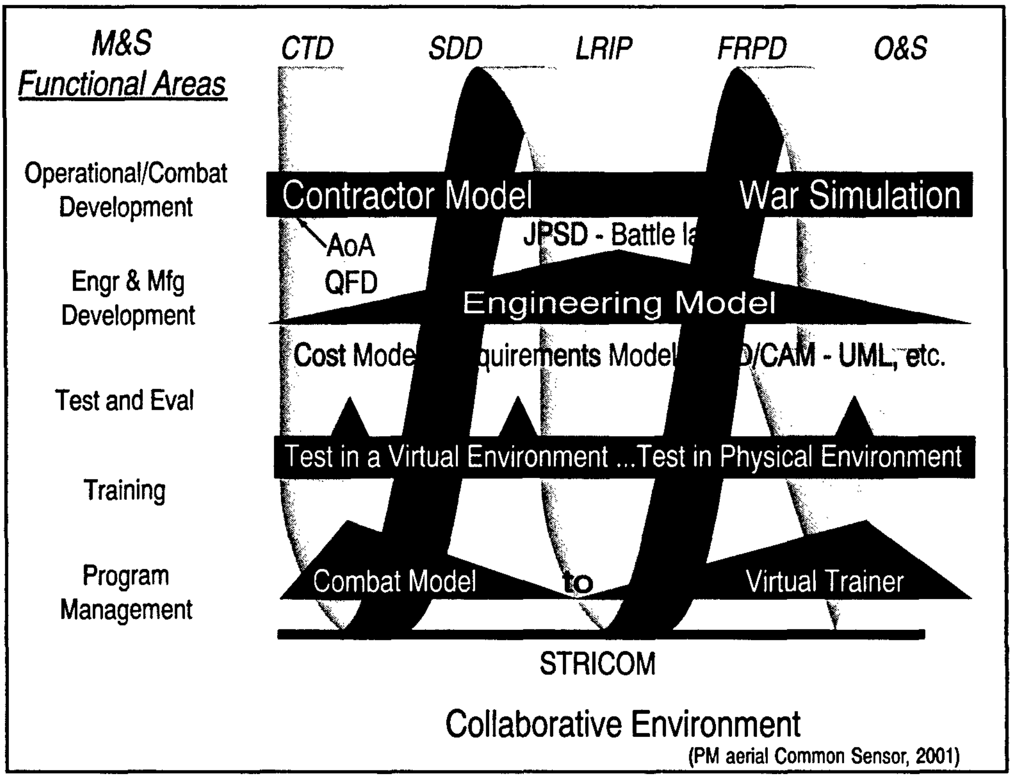


Figure 1. Selected Program Events and Levels of Modeling and Simulation from Functional Areas

Plan, (Ellis, et al., 2002). A Simulation Support Plan provides a means of developing a *roadmap* of simulation integration within the life cycle of a system acquisition.

> The Simulation Support Plan is the plan identifying utilization of models and simulations over the lifecycle of an acquisition program from concept and technology development to system disposal. It is a document that evolves as the system matures. Because SMART is an enabler to ~~the~~ meeting Army Transformation objectives, the Simulation Support Plan will discuss how SMART is implemented in the program. (Ellis, et al., 2002, p. 69)

One notional representation of the source and level of simulation contribution across the system life cycle is shown in Figure 1. Some key events in the life cycle are also noted for reference purposes. In the SMART concept, the Integrated Concept Team and the Integrated Product Team, under the leadership of acquisition managers, interweaves the use of models and simulations into the system life cycle. The team plans and schedules activities that lead to successful materiel acquisition.

The Hypotheses of Mutual Benefit

Not clear in the literature is the contribution that organizational training simulations may make to the acquisition process or the contribution the acquisition process may make to organizational training simulations. By the term organizational training simulation, we are referring to a composition of various simulation systems that attempt to represent a military organization for organizational training purposes. For the Army, the CCTT is one example. The Distributed Mission Trainer is an example for the Air Force.

What is significant is that organizational training simulations go beyond stand-alone simulators to encompass a composite of the various systems found in the organization. Simulation of an organization potentially enables savings based on scale rather than simply savings gained through direct one-to-one, simulator-to-system simulation.

Our hypothesis is that not only can these organizational training simulations help, primarily through the advantages of scale, a weapon system development during its life cycle, but also outflow from the weapon system development may advance model fidelity within the organizational training simulation.

Synergy between the Two

From a theoretical perspective, simulation success hinges on software development factors identified by McCabe (1980) and listed below.

Fidelity: the accuracy of the representation when compared to the real world for the applications that it was intended.

Modularity: allowing a program to be created from individual modules.

Expandability: allowing the expansion of requirements for storing data and scalability in computing.

Self-Descriptiveness: clarity in terms of explaining how a system works through easy to use Graphical User Interfaces (GUIs) and tools, visibility of behaviors and models, documentation, and self-descriptiveness of code.

Self-Explanatory: ability to understand model output.

Software System Independence: shows how much a program depends on its computational system as well as reduces the burden on human support personnel.

Interoperability: allowing the use of standard communications protocols so that it can work with other simulations.

Data Commonality: allowing the representation of data in a standard form that is applicable across all domains and promotes reuse.

Our formal research survey, of selected (from industry and government) simulation professionals identified by the Director of the Army Modeling and Simulation Office, revealed that of the above factors Self-Descriptiveness, Interoperability, and Data Commonality were statistically ranked higher in importance in terms of creating capable and reusable models and simulations (Wilcoxon Signed Rank Test, $p = .1$).

"From the acquisition perspective, interoperability and data commonality may prove very helpful."

That is to say, leading simulation professionals view interoperability and data commonality along with self-descriptiveness as the most significant factors in terms of simulation capability and reusability. Further, funding priorities within the simulation community reflect that importance. For example, over the past decade, the Defense Modeling and Simulation Office funded and created: (1) the High Level Architecture for simulation interoperability and (2) Synthetic Environment Data Representation and Interchange Specification toward data commonality.

From the acquisition perspective, interoperability and data commonality may prove very helpful. For example, a Program Manager of a new system development may leverage interoperability and data commonality investments by taking advantage of the scale implications. Specifically, interoperability and data commonality enable composition of simulation systems involving scores, if not hundreds, of synthetic entities.

While emphasizing interoperability and data commonality, the simulation community, based on our survey, may not emphasize model fidelity as strongly as they do other simulation attributes. This may result in the acquisition community having models of new systems that are of insufficient fidelity to realize the benefits and savings of the SMART approach to system acquisition. From an acquisition perspective that infers, with the advent of a new materiel system, the burden of model development for the new materiel rests with the acquisition manager.

Compounding the possible fidelity shortfall of models for new materiel in an organizational training simulation is the need for increasing fidelity of the new model. This is brought out in part by the data evolution phenomenon identified by Ellis, et al. (2002) and shown in Figure 2. As systems develop over time, data requirements experience increasing need for higher fidelity and greater breath

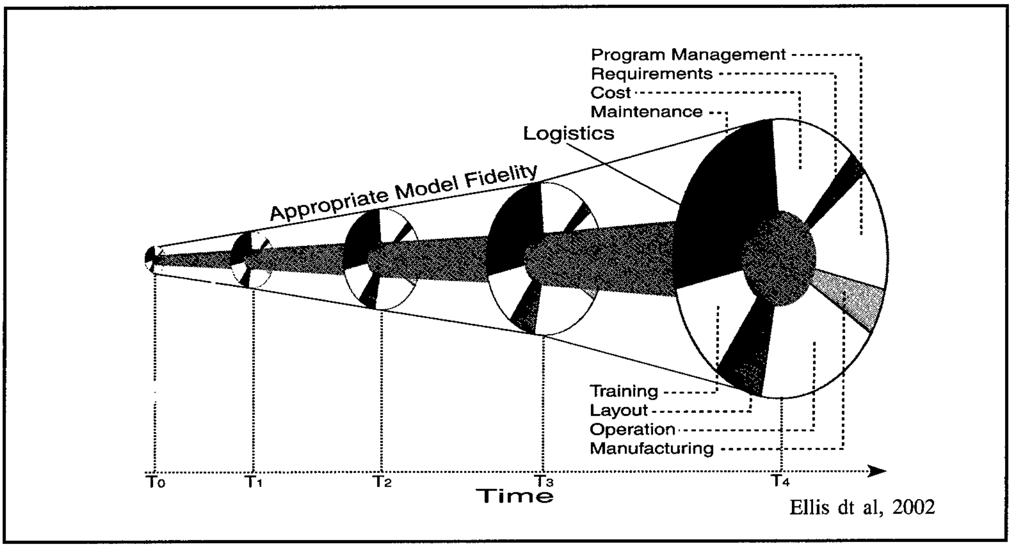


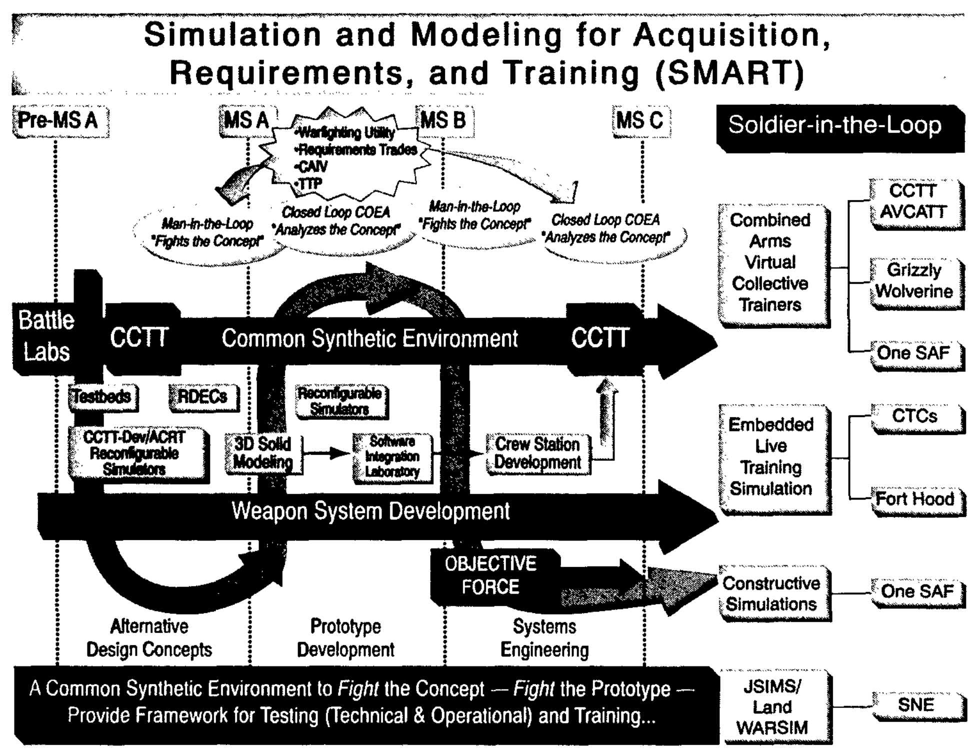
Figure 2. Growing Requirement for Fidelity and Breath in the Distributed Product Description

while expanding to more activities distributed within an organization and across organizations. Therefore, existing models of new materiel acquisitions sufficient for stand-alone analysis may need further refinement to be suitable in an organizational context.

The U.S. Army Program Executive Office for Simulation, Training, and Instrumentation maintains that synthetic environment enhancements can occur concurrent with weapon system development. This may happen as model fidelity enhancements are funded so as to enable representation of a new weapon system phenomenon. Hence the state of simulation may advance along with weapon system development as implied by the *Snake Chart* in Figure 3. The key elements of this chart are the two development lines (simulation environment and weapon system) interwoven by a line that *snakes* from one development effort to the other. The winding of the Snake represents the flow of insights, deliberately common databases, algorithms, software routines, architectures, processes, etc from one development effort to the other over time. The flow emphasizes the feedback into simulation development that can be accrued during the materiel acquisition (weapon system) development and vice versa. For example, modeling of a weapon system in a simulation may yield insights that advance the state of the weapons system development. Likewise, weapon system development may create new reusable weapon system models and simulations for future simulation system development, thereby promoting synergy between weapon system development and synthetic environment development.

Program Descriptions

To examine the hypothesis of mutual benefit, a case study needed to have an



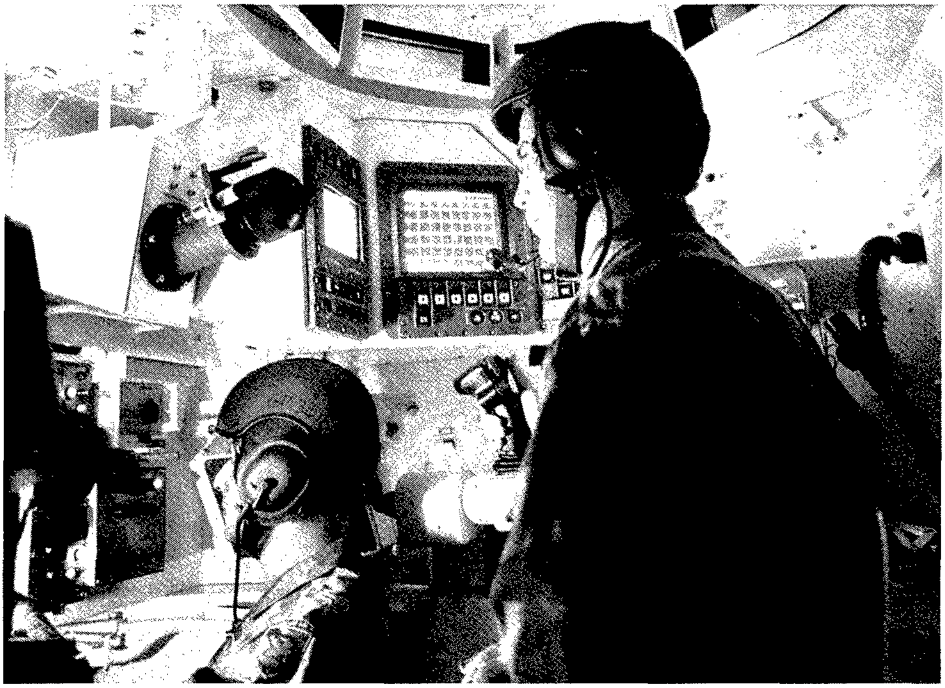
(Program Executive Office Simulation, Training and Instrumentation, provided by J. Tomasello, personal communication, May 1, 2002)

Figure 3. "Snake Chart"

organizational training simulation and a materiel acquisition system interact as described above (Yin, 1994). For this research, the materiel system called the BCIS managed by Product Manager, Combat Identification was identified as the acquisition program. The CCTT simulation was identified as the organizational training simulation system. These two systems interacted with each other during the BCIS acquisition.

The CCTT is the first virtual simulation training system developed under the Combined Arms Tactical Trainer (CATT) program (Figure 4). The CATT is acquiring a group of high-fidelity, interactive, manned simulators for training. The CATT program provides command, control, and communications workstations, and exercise control stations. After Action Review systems and the Virtual Combined Arms synthetic environment to support virtual training organizations up to battalion/task force level.

Using interoperability and data commonality, the CCTT system trains tank and mechanized infantry organizations from platoon to battalion task force, including cavalry scout platoons and heavy cavalry troops on collective tasks. The CCTT system offers commanders the opportunity to develop and tailor structured exercises based on mission, enemy, troops, terrain, and time available to meet the training



Courtesy of Lockheed Martin Corporation

Figure 4.
Training in the Close Combat Tactical Trainer Virtual Environment

plan and objectives of the organization (Figure 5). CATT virtual synthetic environment includes large-scale virtual terrain representation with natural synthetic environment effects (e.g., weather effects), accredited computer generated forces replicating adjacent, supporting, and opposing forces (Barlow, 2003).

Part of the Combat Identification program, theBCIS, is a millimeter wave device that is integrated into the vehicle subsystems to aid in target identification. The intent of the device is to reduce fratricide (friend on friend combat engagement). The BCIS attempts to reduce fratricide by identifying at the gunner's sights contacts as *friendly* if the contact is equipped with the BCIS or *UNKNOWN* if otherwise. The BCIS works effectively through smoke, dust, sand, rain, fog, and beyond visual range. A typical BCIS event occurs with Abrams or Bradley platforms interacting with other friendly and opposing combat vehicles as well as noncombatant vehicles (Maddux, Kwiecien, & DeChiaro, 2001; J. Tomasello, personal communication, May 1, 2002).

Mutual Benefit

Operational testing of the BCIS was needed in order to assist the U.S. Army in making an acquisition decision. A traditional approach to such testing would be to conduct a live exercise in the field using real vehicles equipped with BCIS. Because of the investments of the simulation community in interoperability and data commonality, an alternative to live field-testing existed in the Close Combat


Courtesy of Evans & Sutherland

Figure 5. Screen Shot from Close Combat Tactical Trainer Simulator

Tactical Training system. Using an organizational training simulation to replace an operational test is innovative as well as not typically considered at this stage of the system life cycle. Yet, due to a creative approach, this alternative was allowed to develop.

J. Tomasello (personal communication, May 1, 2002), winner of a SMART 2002 award for his efforts (Lunceford, 2002), clarifies the two choices:

> The goal was to determine if Battlefield Combat Identification System made a greater contribution than other situational awareness equipment choices. For the operational component of the assessment, [Program Manager] PM Combat Identification had the choice of: (1) going to the National Training Center and standup a battalion force of combat vehicles with the equipment to be tested or (2) utilizing the Close Combat Tactical Trainer facility at Ft. Hood, Texas for the operational evaluation. (J. Tomasello, personal communication, May 1, 2002)

The estimated cost of pursuing a live field-operational test was approximately $20 million (J. Maddux, personal communication, n.d., 2003). For case study research, Yin (1994) indicates that archival records are a source of evidence to explain or provide context for such case evidence. As such, General Accounting Office (GAO) reports can provide some insight as to the validity of this $20 million dollar estimate. While recent GAO estimates do not delineate actual exercise costs at the National Training Center, they do indicate that the Army spends *more than a $1 billion annually* to provide training for 123 battalion at its three Combat Training Centers (Schuster, 1999). This includes far less expensive, non-mechanized battalion rotations at the Joint Readiness Training Center. Nonetheless, that is still approximately $8.1 million per battalion in FY 1998 dollars or $8.8 million in FY 2001 dollars.

The last reported GAO cost estimates for unit costs for mechanized battalion training at the National Training Center is $4 to $6 million per unit for 1983 to 1985 ($7.1 to $10.6 million 2001 dollars using the Bureau of Labor Statistics Inflation calculator http://www.bls.gov/cpi) (Conahan, 1986). These figures do not include National Training Center operating and instrumentation costs, which would be prorated across the number of units training on an annual basis. The GAO reports that those costs ranged from $62 to $90 million annually for the 1983 to 1985 period (Conahan, 1986). Additionally, the GAO estimates do not include low rate production costs, equipment upgrades, and other associated costs necessary to actually implement a field test using BCIS equipment. In this context, a $20 million estimate for BCIS testing does not appear to be unreasonable.

On the other hand, the total cost for conducting BCIS testing in CCTT actually came to approximately $2 million. That cost included related modeling efforts, incorporation of models within CCTT environment, expanding the data collection and reduction capabilities, and performing data analyses (J. Maddux, personal communication, n.d., 2003). The same level of testing was achieved without imposing on the National Training Center. Further, the potential for conducting additional scenarios and events not possible in a live setting due to safety and environmental restrictions was possible. J. Tomasello (personal communication, May 1, 2002) explains the advantages.

> Even though configuring the Close Combat Tactical Trainer and designing the evaluation to replicate the different options took a year and involved the cooperation of the Army Test and Evaluation Command and the Army Materiel Analysis Activity (this would have had to been done anyway), the saving from not having to modify equipment, operate it in the field, or endanger personnel during real operations all were savings that could be identified in real time. Further, the collaboration between Developer, Tester, and Trainer yielded additional benefits in quality improvements to Battlefield Combat Identification System that may not be as easily quantified. The results were part of the test. The data were actually used. General Kern could say Battlefield Combat Identification System does reduce the incident of fratricide. That was all done in the simulation as part of

> the operational evaluation. We could readily do night, fog, and rain, etc. on demand that National Training Center could not. (J. Tomasello, personal communication, May 1, 2002)

With estimates of a 90 percent cost savings, lead-times within the planning cycle, and with increased flexibility and capability, J. Maddux (personal communication, n.d., 2003), Product Manager for Combat Identification, funded the modeling efforts to represent the BCIS in the CCTT. One essential aspect for this funding required that the BCIS simulator code, called the Battlefield Identification System Environment and Performance Simulator, be put in the CCTT code. J. Tomasello (personal communication, May 1, 2002) indicates how that was done:

"One of the key lessons learned from this case study is the SMART approach taken by the key leaders."

> Georgia Tech Research Institute developed the Battlefield Identification System Environment and Performance Simulator, initially a server based application that replicated what happened when you probe somebody with the Battlefield Combat Identification System millimeter wave system. We took the Battlefield Identification System Environment and Performance Simulator off the server and embedded Battlefield Identification System Environment and Performance Simulator into Close Combat Tactical Trainer code. We designed the software so it was distributed to the manned modules and removed the server as a single point of failure. (J. Tomasello, personal communication May 1, 2002)

This enabled the CCTT to support testing of the Battlefield Combat Identification System. Trials were conducted and the Army Test and Evaluation Command and the Army Materiel Analysis Activity utilized the accredited, simulated battle trials generated in theCCTT in their test and evaluations plans, replacing the live simulation trials that were avoided.

A SMART APPROACH TO ACQUISITION

One of the key lessons learned from this case study is the SMART approach taken by the key leaders. Elements of that approach include innovation, leadership, collaboration, and an active involvement of the Integrated Product Team with the goal of wisely using all possible simulation alternatives. PM innovation and creativity was paramount to taking on the risk of providing resources to pursue the unproven route of using organizational training simulations to replace operational field testing. In essence, PM Combat Identification took advantage of the opportunity by being open to this non-traditional approach.

Leadership was essential by both the PM Combat Identification and PM CATT in order to capitalize on the opportunity. Collaboration was the means by which things were accomplished. PM Combat

Identification and PM CATT cultivated collaboration across their organizations and participants from the Army Test and Evaluation Command, the Army Materiel Analysis Activity, III Corps, Lockheed Martin, Science Applications International Corporation (SAIC), DSCI, Pulau Electronics, and Georgia Tech Research Institute through their leadership of the Integrated Product Team. In the words of Mr. J. Tomasello (personal communication, May 1, 2002):

> The SMART process changes are major. What SMART does is break barriers down giving everyone a common goal. Collaboration is of the utmost importance. For a process team, you have got to agree from the start, what your objectives are, what your requirements are. (J. Tomasello, personal communication, May 1, 2002)

Expanding on these insights, cooperation between the acquisition community and the training system development community also makes for faster, more efficient and effective transition of high-fidelity, software updates for materiel systems. J. Tomasello (personal communication, May 1, 2002) explains one process mechanism that has reduced training simulation software lead-times.

> Scratching the surface of reuse and SMART is our basic program for our M2A3 Bradley Fighting Vehicle and M1A2SEP Abrams Tank. We take the vehicle software and have it modified with a wrapper around it so that it runs in Close Combat Tactical Trainer. When General Dynamics (system manufacturer) puts out an update, we have a third party — OASIS — ... deliver the code with the wrapper to CCTT as well as Advanced Gunnery Training System, the Maintenance Trainer and the Driver Trainer. It is a library they deliver that we take and drop into our systems, Close Combat Tactical Trainer, manned modules, everything. The big advantage of this process is that the tank commander, gunner, loader, etc. sees the latest version of the software in Close Combat Tactical Trainer. You don't want one version of the interface software being fielded with the weapons systems and another version of the software in the Close Combat Tactical Trainer. (J. Tomasello, personal communication, May 1, 2002)

This cooperation between the materiel developer and the organizational training system developer enables training systems to be up-to-date when new materiel system updates reach the field. This process mechanism may also make it possible to conduct future operational testing in organizational training simulations in an even more rapid fashion then occurred in this case study.

For this case study, leadership found traction through creativity, collaboration, capitalization, and cultivation — all of which may be considered key tenets of SMART. Future acquisition managers may consider promoting cross-domain collaboration, cultivation of a life cycle perspective among team members, and capitalization of Modeling and Simulation (M&S) assets in order to achieve program benefit.

CONCLUSION

With increased realism and the benefits of scale made possible by interoperability and data commonality, organizational training simulations may now provide a significant and credible resource useful in the successful and cost-effective management of a materiel acquisition. This paper identifies key findings from a case study of the use of an organizational training simulation in support of acquisition. A brief overview of the possible mutual beneficial relationship between organizational training simulation and the materiel acquisition system is presented. Examples of explicit strategies of employing training simulation in acquisition and tenets to accomplish these benefits are proposed.

"The acquisition manager is key to achieving synergy between training simulation and acquisition models...."

PM Combat Identification effectively collaborated with PM CCTT and other organizations to create benefit for both programs. Essential to the success was their willingness to take advantage of the inherent attributes of the systems themselves. They capitalized on the scale capabilities of the CCTT to represent a large force of live systems. Using one composite system to represent many resulted in significant cost savings. Secondly, they reused the BCIS existing simulator code in CCTT. This action saved both time and money. Accompanying the resulting cost savings and feedback to BCIS was a synergistic flow of insights, deliberately common databases, algorithms, software routines, architectures, processes, etc. to CCTT.

Also essential to the success of this case study was the *roadmap* of simulation integration created by the Integrated Product Team. Planning is necessary not only for the purpose of coordination, but also to accommodate lead times for simulation integration. In particular, this case study indicates successful planning includes: creating new opportunities by innovate thinking and risk taking; cultivating a total life cycle perspective so as to maximize the potential to create benefit throughout the life cycle; emphasizing collaboration within Integrated Concept Team and Integrated Product Team, and capitalizing on existing models and simulation systems within these communities, to include the training community.

Simulation of a large-scale field exercise was made possible through training simulation strengths in interoperability and data commonality. The acquisition manager is key to achieving synergy between training simulation and acquisition models by addressing the need for increasing model fidelity over time as it relates to the materiel development. Organizational training simulations may not have the priority or perspective that materiel acquisition managers have to develop high fidelity models of new materiel. Thus, the responsibility rests with materiel acquisition managers to develop models of sufficient fidelity for analysis. Existing process mechanisms that currently speed the transfer of model data from materiel acquisition systems into the training simulations may also help speed acquisition model data into training simulations for operational testing purposes.

Given the numerous other simulation systems identified by the earlier references, the use of organizational training simulation is only one set of tools in the acquisition community arsenal. The CCTT is one of those tools. Raising the awareness of the capabilities of the training simulation community to the acquisition community is important for the war fighter, who will reap the benefit from these successes.

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GUARDRAIL COMMON SENSOR

Photo courtesy of the Raytheon Company

LESSONS LEARNED FROM THE EARLY STAGES OF DEVELOPMENT OF THE GUARDRAIL COMMON SENSOR FOR THE RADICAL REDUCTION OF CYCLE TIME

J. Daniel Sherman

Nine key participants from the government and prime contractor were interviewed to identify important lessons learned from the early stages of development of the Guardrail Common Sensor. In addition to in-depth interviews, U.S. Army Communications and Electronics Command (CECOM) historical documents, unclassified government reports, and other public sources were reviewed for information regarding the system's development. The management of the system development deviated from normal acquisition processes in several important ways. These are presented and the implications for flexibility in the acquisition process are discussed.

The history of the U.S. Army operation of Special Electronic Mission Aircraft (SEMA) began during the Vietnam War. The need for signal intelligence (SIGINT) was significant during the Vietnam conflict, and as a consequence, improving the capability of these systems became an important Army priority.

GUARDRAIL DEVELOPMENT PRIOR TO COMMON SENSOR

In 1970, based on the successful development of ground-based systems in Vietnam, the National Security Agency (NSA) under the guidance of its director, Admiral Gayler, initiated the development of an airborne communications intelligence

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(COMINT) system with more advanced capabilities. In February 1971, the contract was awarded to Electronic Systems Laboratories (ESL), a division of TRW, for the development of what would be known as Guardrail I (Swainston, 1994).

During the early 1970's, Guardrail I was followed by a rapid succession of Guardrail systems that included Guardrail II, III, and IV. Guardrail I–IV (GR I–IV) achieved their operational requirements and were each produced on schedule and within budget. These early systems were procured by NSA as Quick Reaction Capability (QRC) programs. They were designed as theatre level assets that led to a long-term requirement for Guardrail as an Army Corps level asset. In early 1976, the Guardrail V (GR-V) program was conceived and ESL continued the program as prime contractor. The GR-V program was planned as a cost-effective, second-generation technology insertion program. In 1977, as a result of the Intelligence Organization and Stationing Study, responsibility for the Guardrail program was transferred from NSA to the Department of the Army, Electronics Command (ECOM, later to be Electronics and Communications Command, CECOM; Rawles, 1989).

"The TDOA capabilities of GR/CS would give the United States a technology advantage over any potential enemy."

Unlike the contracts for GR I–IV, the GR-V program had significantly increased formal data requirements in the areas of logistics, the qualification test program, spare parts program, quality assurance program, and software documentation. However, GR-V was still classified as a limited production urgent system. In this sense, while GR-V lost some of the skunkworks-like characteristics of GR I–IV, it still retained the authorization to proceed as an urgent QRC program with significantly reduced oversight requirements (Moye, 1986; D. Swainston, personal communication, August 3, 2001).

The Guardrail Common Sensor Program

In 1982, while the improved GR-V systems were being completed, a concept began to emerge for an advanced system that integrated other COMINT and electronics intelligence (ELINT) systems with Guardrail. This would be known as the Guardrail Common Sensor (GR/CS). It would combine the Advanced Quicklook (AQL) and the Communications High Accuracy Airborne Location System (CHAALS) with Guardrail to form a corps level signal intelligence system with an integrated platform and a single ground processing facility (R. Sciria, personal communication, August 9, 2001).

Development of the Quicklook ELINT system (the predecessor to AQL) had begun in the early 1970s. With GR/CS, a new generation of Quicklook would be developed that employed the technology known as Time Difference of Arrival (TDOA). This technology utilized triangulation from multiple aircraft to obtain location coordinates for the emanating source of a radio signal. The TDOA capabilities of GR/CS would give the United States a technology advantage over any potential enemy. However, in order to achieve the integration for the GR/CS system, the AQL would require miniaturization due to weight and space limitations. The contractors for the Advanced

Quicklook were UTL Corporation in Dallas (for development) and Emerson Electronics and Space Division (ESCO) in St. Louis (for production). The second system that was integrated into GR/CS was the CHAALS precision COMINT location system. This geolocation system for communications emitters utilized both the TDOA technology and Differential Doppler technology, and International Business Machines (IBM) continued as the contractor (CECOM, 1994; Jette, 1996).

The basic operational concept behind GR/CS was to authorize one GR/CS system per aerial exploitation battalion in the military intelligence (MI) brigade of each corps. A standard system would consist of 12 aircraft that would fly operational missions in sets of two or three. The ground processing for GR/CS would be conducted in the integrated processing facility (IPF). The IPF would be the control, data processing, and message center for the overall system. It consisted of four 40-foot trailers with 28 operator stations. Interoperable data links would provide microwave connectivity between each aircraft and the IPF. Reports would then be transmitted to the Commanders Tactical Terminals (CTT). The CTTs would be located at up to 32 designated intelligence centers and tactical operations centers. The automated addressing to CTT field terminals would provide automated message distribution to tactical commanders in near real time. The system later added a satellite Remote Relay System (RRS). With this system, intercepted SIGINT data could be transmitted to any location in the world (CECOM, 1987, 1988; Hall, 1990; U.S. Army, 1994). The first GR/CS was completed in 1991 and throughout the 1990s development continued with an intensive program of technology insertion through pre-planned product improvements.

Lesson 1. A High Technology Readiness Level Reduces Risk

A number of important factors contributed to the success of the Guardrail program. One of the most significant factors that influenced budget, technical performance, and particularly schedule in each phase of the Guardrail development was the level of technology readiness or maturity. When the program started in the early 1970s, ESL had already developed an extensive base of relevant knowledge among its engineering staff in its laboratories. This knowledge had developed through their experience with ground-based remote COMINT systems in Vietnam. In addition, at ESL, other Department of Defense (DoD) programs provided a synergy in the development of the technologies that would be required for Guardrail.

"One of the most significant factors that influenced budget, technical performance, and particularly schedule in each phase of the Guardrail development was the level of technology readiness or maturity."

The extensive base of expertise at ESL (and later CHAALS expertise at IBM and AQL expertise at UTL Corporation) was only one contributor to the level of technology readiness. Another important contributor was the development strategy that was first instituted at NSA and adopted by ESL, and later adopted by the Army program offices. This development strategy was multidimensional, but one key element was a focus on minimizing technological risk and making design decisions based on technological maturity. However, this strategy included a program of systematic pre-planned product improvements based on technology insertion. The technologies in areas such as integrated circuits, direction location finding technology, signal processing technology, computer hardware and software were evolving rapidly during this period. The Guardrail program offices and ESL believed that as each successive system was completed and fielded, the next system could be incrementally upgraded as a new generation Guardrail system with more advanced technology (R. Ohlfs, personal communication, August 6, 2001).

"The strategy of minimizing technological risk and making design decisions based on technological maturity worked well throughout the 1970s and 1980s."

The laboratories at CECOM also played an important role during Guardrail development. G. Morris (personal communication, August 1, 2001) of CECOM noted that in supporting the CHAALS and the Advanced Quicklook programs the CECOM laboratories helped solve numerous technical problems that allowed these systems to mature sufficiently for integration into the Guardrail Common Sensor.

The strategy of minimizing technological risk and making design decisions based on technological maturity worked well throughout the 1970s and 1980s. However, both C. Dubusky (personal communication, August 6, 2001) of the Army GR/CS program office and D. Swainston (personal communication, August 3, 2001), retired ESL program manager, believed that the program began to deviate from this strategy in the 1990s. With GR/CS System 2 the technological envelope began to be pushed too far, too soon. This resulted in increased levels of technological risk, and subsequent problems with cost, schedule, and technical performance. This is perhaps a lesson in organizational learning itself. Each successive generation of managers (both government program office and prime contractor) must learn from the successful and failed decisions of preceding programs. In the case of GR/CS System 2, what had been learned in the past in terms of development strategy seems to have been forgotten.

Lesson 2. Utilizing an Open Architecture

C. Dubusky (personal communication, August 6, 2001), chief engineer at the government project office, and H. Redd (personal communication, August 7, 2001), ESL field representative, observed that one of the problems projects encounter in areas where the core technologies are advancing rapidly is potential for the system to be obsolete before it is ever fielded. Because Guardrail was becoming increasingly software dependent with each successive generation, to address this problem the Guardrail government program office and ESL instituted two initiatives. The first was the application of real time tactical system processing architecture that was based on the use of international standards and the use of a seven layer Ada protocol. The second initiative was the Advanced Tactical SIGINT Architecture initiative that employed a unified architecture that was bus oriented and employed all Ada software. Thus, the architecture and the software standards became the basis for the system, not the vintage of computer hardware. As new computer and bus technology were introduced, so would the method of adapting to the established standards. In this way, as computer hardware rapidly evolved, the software for successive generations of Guardrail could be rapidly adapted.

It should also be noted that this approach relied heavily on commercial off the shelf components (COTS). In fact, by the time GR/CS System 1 was being produced, 66 percent of 1176 components were commercial off-the-shelf. Furthermore, 91 percent were common with other systems. In essence, a key component of the acquisition strategy could be described as evolutionary acquisition. A core capability is fielded with a modular open structure and the provision for future incremental upgrades. Each successive upgrade would then occur as a block of pre-planned product improvements (R. Ohlfs, personal communication, August 6, 2001; D. Swainston, personal communication, August 3, 2001).

Lesson 3. The Implementation of a Program

In the context of the Cold War, and under conditions of rapid technological advancements, the normal acquisition processes were viewed to be inadequate by the Guardrail program office. H. Redd (personal communication, August 7, 2001), who worked for the government program office before moving to ESL, indicated that based on the failed experience of the Communications and Electronics Forward Looking Flying Lancer (CEFLY Lancer), program office staff were convinced that a radically different acquisition strategy was needed. This strategy focused on schedule performance and consisted of several important components. First, and most importantly, was the approval of a Quick Reaction Capability program (QRC program). Given the urgent nature of the program, and the fact that top Pentagon officials were convinced of the criticality of the schedule, the program office was able to obtain a letter signed by a four-star Army general and a four-star admiral (NSA) approving the QRC program. This letter was later referred to as the "eight-star letter," and it allowed the program office maximum flexibility to modify and bypass existing acquisition processes.

"As new computer and bus technology were introduced, so would the method of adapting to the established standards."

For example, one of the factors that contributed to the schedule and cost problems with the CEFLY Lancer was the requirement to comply with extensive military specifications. S. Pizzo (personal communication, August 28, 2001), an engineering manager with the government program office, observed that the Guardrail program office understood that the great majority of these elaborate specifications would not be critical to Guardrail's performance, maintainability, reliability, etc. However, to comply with such requirements would result in vastly reducing the ability to use existing *off-the-shelf* equipment and components. This would affect schedule and cost. In other words, the incremental benefit associated with many of the specifications could not be justified based on the schedule and cost implications. With the approval of the QRC reduced cycle time program, numerous non-critical milspecs were eliminated or modified.

In addition, the program office understood that the standard Army development process with the usual milestones and approvals would reduce their ability to field the system in the time parameters that were needed in the Cold War environment. In light of this, the QRC program allowed Guardrail to be funded almost completely as a production program. In actuality, there was engineering development occurring as the program progressed, but it was funded under the production contracts. In essence, the acquisition strategy was to begin with the baseline Guardrail system and then evolve the system through blocks of pre-planned product improvements using mature, but state-of-the-art existing technology (C. Dubusky, personal communication, August 6, 2001). In this way the scheduling ramifications associated with the standard Army acquisition process would be reduced. Of course, such an approach would not be advisable for programs with extensive engineering development requirements or large production runs. In the case of Guardrail, this approach worked because the technology was mature, considerable COTS components could be used, and each system was comparatively unique or customized.

"...while engineering development activity was included in the production contracts, it was not funded in the usual way as cost plus incentive fee contracts."

Former ESL Guardrail program manager, T. Black (personal communication, August 3, 2001), observed another important ramification associated with the use of production contracts. Almost all of the contracts were fixed price or fixed price plus incentive fee contracts. This forced the contractor to be extremely accurate in cost estimating prior to program start. Because of ESL's depth of expertise in all of the major technologies, cost estimating was generally very accurate.

As noted previously, while engineering development activity was included in the production contracts, it was not funded in the usual way as cost plus incentive fee contracts. C. Dubusky (personal communication, August 6, 2001) of the government program office observed that this approach to the acquisition strategy on the part of the government resulted in disciplined cost containment.

Lesson 4. When the Schedule for Fielding Is Urgent

S. Pizzo (personal communication, August 28, 2001) of the Guardrail program office observed that the assumption that competition in defense contracting universally results in superior performance in terms of cost, schedule, and technical performance may be incorrect. Competition should predictably achieve the desired results under most conditions. However, there are conditions under which the normal competitive process in government contracting will not result in the highest level of technical and schedule performance.

Guardrail seems to have been one of those programs.

When the schedule for fielding is urgent, the technology is evolving rapidly, and the defense contractor that developed the first (baseline) system is by far the leading firm in terms of relevant system specific technical expertise, then a sole source contract may be required. In the case of Guardrail, the initial contract for Guardrail I was competitive. Thereafter, the contracts were sole source to ESL as prime contractor (with the other pertinent subcontractors). This resulted in several important advantages for schedule and technical performance.

First, the sole source contracts for the sequence of systems following Guardrail I allowed for requirements to be set through dialogue. The usual situation would be for the requirements to be specified prior to a request for proposals (RFP). Thus, requirements would be set in advance. In the case of Guardrail, ESL engineers and government engineers worked very closely to develop specifications for each successive system within the general requirements specified by the Training and Doctrine Command (TRADOC). However, TRADOC generally deferred to the judgment of the program office, and this allowed for specifications to be developed through joint dialogue between engineers at ESL and the government (D. Swainston, personal communication, August 3, 2001).

R. Ohlfs (personal communication, August 6, 2001), former chief systems engineer at ESL, suggested that this approach worked well because ESL could effectively identify requirements that might not be cost effective or requirements that could adversely affect the schedule. Thus, the dialogue tended to influence the process so that design decisions approached the optimum.

Both G. Morris (personal communication, August 1, 2001) of CECOM and D. Swainston (personal communication, August 3, 2001) concluded that TRADOC contributed to the requirements stability and funding stability of the program. This was very advantageous to Guardrail because it allowed the engineers to work in an environment that minimized dysfunctional change. When changes or new capabilities were presented by TRADOC, the Guardrail program office would assess the technical feasibility and cost implications and introduce the change in the next successive generation of pre-planned product improvements. However, TRADOC basically deferred to the judgment of the technical experts at CECOM and ESL as to what was and was not cost effective or technically feasible. In this way, the program benefited from an environment of stability.

"...the dialogue tended to influence the process so that design decisions approached the optimum."

Lesson 5. Achieving Effective Integration for the Common Sensor

From the beginning of the Guardrail program, internal integration at ESL had been managed very effectively. ESL had utilized a project-matrix structure with a functional engineering organization. The functional areas included laboratories, and the organization was based on engineering specializations. The Guardrail program office obtained engineers from the various functional areas. These assignments were typically full time until an individual was reassigned to another project. In addition, the laboratories or functional groups would provide technical support to the Guardrail program office on a task-by-task basis (R. Ohlfs, personal communication, August 6, 2001).

The program office had a team of assistant program managers that each managed a major subsystem or functional area. One of the former ESL program managers, T. Black (personal communication, August 3, 2001), indicated that the team of assistant program managers met on a near daily basis because of the high degree of interdependency among the various systems. To keep the program on schedule, program evaluation and review technique (PERT) was used extensively, and schedules were reviewed weekly on a task-by-task basis. Even before concurrent engineering became common, ESL was applying the basic processes in the Guardrail program (R. Ohlfs, personal communication, August 6, 2001).

"To keep the program on schedule, program evaluation and review technique (PERT) was used extensively, and schedules were reviewed weekly on a task-by-task basis."

Prior to Common Sensor, external coordination with the various subcontractors was minimally complex. As prime contractor, ESL assumed responsibility for system integration. With the advent of the Common Sensor and the addition of the CHAALS and AQL systems, integration increased in complexity. ESL and the Guardrail program office at Ft. Monmouth developed interface control documents to specify the necessary interfaces with equipment being developed and produced by IBM, ESCO, Beech, Unisys, UTL Corporation, and other contractors.

S. Pizzo (personal communication, August 28, 2001) and G. Morris (personal communication, August 1, 2001) on the government side and T. Black (personal communication, August 3, 2001) on the contractor side observed that the interface between ESL and the government program office was much like an integrated product team (IPT). Long before these came into vogue in the 1990s, ESL and the Guardrail program office were implementing this type of interorganizational project coordination. George Morris (personal communication, August 1, 2001) observed that when IPTs were formally implemented in the 1990s, they tended to be leaderless groups and decisions tended to be reached by consensus. In some instances this worked well, but in other cases the consensual decision making simply did not work. G. Morris (personal communication, August 1, 2001) noted that in the 1980s, prior to the formal implementation of IPTs, the interorganizational teams in the Guardrail program were not leaderless. Typically, the government program office retained final decision authority. However, as a general practice, there was deference to the judgment of those who had the greatest technical knowledge on a particular matter. This approach seemed to work more effectively than the leaderless IPT approach.

In general, the government program office and ESL effectively managed the system integration. However, there was one significant exception. This was the management of the weight for the Beech aircraft during GR/CS System 3 (CECOM, 1992). This was a miscalculation that Beech, ESL, and the Guardrail program office did not discover until System 3 was being tested. This miscalculation resulted in the need to re-engine the aircraft, and this led to serious delays in the completion and fielding of GR/CS System 3 (R. Ohlfs, personal communication, August 6, 2001; Rawles, 1990). The problem could have been avoided if Beech, ESL, the other contractors, and the Guardrail program office had been adequately monitoring the weight problem. If discovered earlier, the replacement of engines on the Beech aircraft could have then occurred concurrently so that the original schedule could have been achieved.

In any case, G. Morris (personal communication, August 1, 2001) of CECOM concluded that integration is facilitated when there is a single prime contractor with multiple subcontractors, and the prime contractor assumes total responsibility for integration. As Guardrail moved into the Common Sensor program, the CHAALS and AQL systems were furnished to ESL through the government program office as government furnished equipment (GFE). ESL had responsibility for integration, but the relationships were ostensibly different because IBM was not a subcontractor to ESL for CHAALS. Neither were UTL Corporation or ESCO subcontractors to ESL for AQL.

Like G. Morris (personal communication, August 1, 2001) and S. Pizzo (personal communication, August 28, 2001), of the Guardrail program office, observed that systems with multiple prime contractors have more complex integration problems. Just as the Navy Battle Group Passive Horizon Extension System (BGPHES) suffered from extensive integration difficulties due to multiple government project offices with multiple prime contractors, as GR/CS began to move in a similar direction, integration became increasingly problematic.

Lesson 6. A Corporate Culture Can Affect the Success of a Program

Given the large learning curves associated with system specific technical knowledge on complex defense systems, continuity in personnel can be a very important contributor to schedule and technical performance. This is not to say that a continuous infusion of new talent is not necessary. This, too, is essential to any engineering organization. However, managing turnover and retention is clearly a problem of optimization.

T. Black (personal communication, August 3, 2001) and D. Swainston (personal communication, August 3, 2001) observed that at ESL a core group of engineers worked on the program for a number of years. In fact, as many as 100 engineers worked on the Guardrail program at ESL for a duration of 15 years. Since each Guardrail program was successive, there were no gaps in time where a large amount of turnover and new hiring had to occur. This continuity clearly facilitated organizational learning and the enhancement of the extraordinary base of expertise at ESL.

"...systems with multiple prime contractors have more complex integration problems."

T. Black (personal communication, August 3, 2001) and R. Ohlfs (personal communication, August 6, 2001) suggested that several important factors contributed to ESLs ability to retain such a talented cadre of engineers. First, ESL was very competitive in terms of salary and benefits. This allowed the TRW division to attract and retain highly talented individuals. Secondly, the corporate culture created an environment that made ESL a very collegial and enjoyable place to work. From the very beginning, William Perry (who would later become Secretary of Defense) tried to create a very close knit, cohesive climate at ESL. Even as the company grew larger and became a division of TRW, ESL still maintained a highly cohesive and supportive culture.

"...the corporate culture created an environment that made ESL a very collegial and enjoyable place to work."

A third factor that characterized ESL was a corporate culture that emphasized flexibility. To illustrate, in the early 1980s, R. Ohlfs (personal communication, August 6, 2001) had considered leaving ESL. His reasoning was based on the fact that he was spending an inordinate amount of time on functional management tasks, and he missed spending the larger proportion of his time on purely technical work. He discussed his sense of diminishing job fulfillment in terms of management responsibilities with the president of ESL, Don Jacobs. Jacobs' response was characteristically atypical. He simply said that ESL needed to create a work environment where talented and self-motivated people are free to do what they do best. As a consequence, the company introduced a type of a dual career ladder where exceptional engineers could progress in a technical track and provide technical leadership in the company without being burdened with managerial responsibility. As a consequence, R. Ohlfs (personal communication, August 6, 2001) stayed another 17 years.

A fourth and perhaps most important factor that contributed to retention was that the engineers working on the Guardrail program had a collective vision for where the technology could eventually go. Furthermore, they understood the national importance of their work in the context of the ominous threat of the former Soviet Union. The combination of these important factors contributed to the continuity in the base of expertise that was successfully maintained at ESL.

THE IMPLEMENTATION OF A PROGRAM

Clearly not all of the observations from the Guardrail program would apply to the development of other defense systems. However, consistent with contingency theories of management, these observations may be useful in the identification of determinants for the implementation of a program with a radical reduction in cycle time, and the identification of important characteristics of those programs.

Figure 1 summarizes necessary conditions and important characteristics of programs that require radically reduced schedules based on the observations and lessons learned that are presented in the preceding sections. Such programs are only necessary when the time parameters for the development, production, and fielding of a system are critical. These conditions typically arise when an emerging threat is evolving rapidly, and in

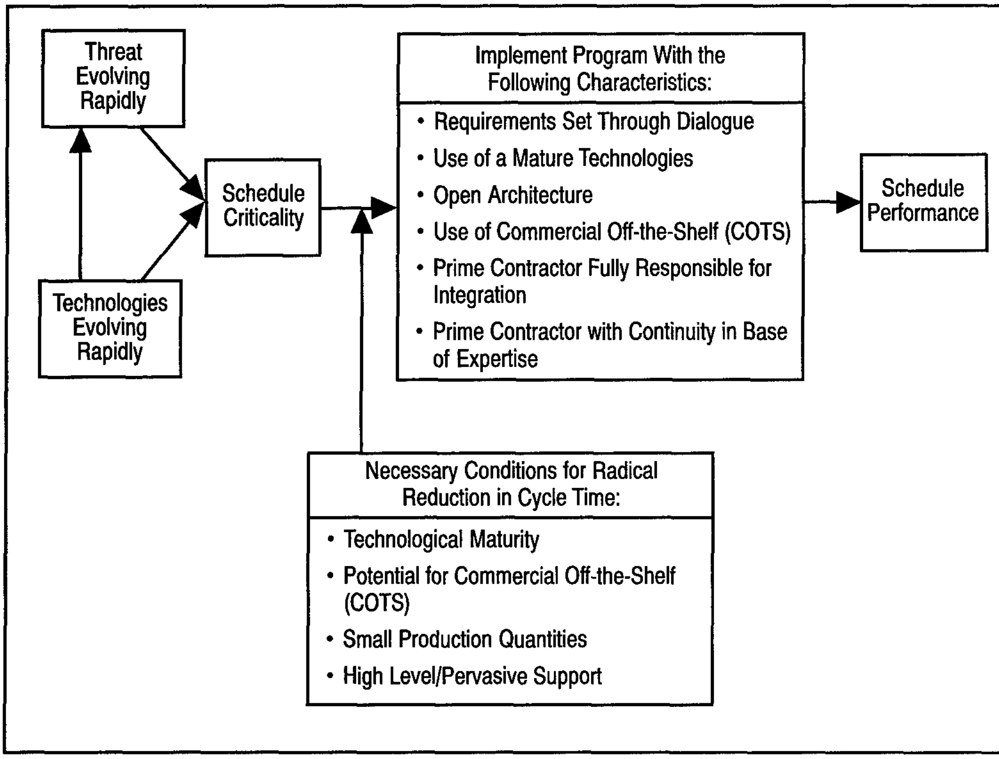


Figure 1.
A Model of Determinants with a Radical Reduction in Cycle Time

many cases where certain key technologies are evolving rapidly (thus affecting the evolving threat).

While schedule criticality is assumed for a program with a radical reduction in cycle time, there are other necessary conditions that must exist for the implementation of such a program. First, while the core technologies will be state-of-the-art, they must be sufficiently mature to avoid significant engineering development time in the schedule. Secondly, a high potential for technology insertion in the form of COTS technologies will reduce development time. Third, systems with small production quantities are advantaged by the fact that the latter stages of development and initial stages of production can occur concurrently. Furthermore, iterative modifications can occur as a result of testing without significant cost or schedule implications. With systems requiring large production runs this is not possible. Fourth, as was the case with Guardrail, such programs require high level and pervasive support to ensure adequate funding and the budgetary stability necessary to optimize schedule.

Assuming that the necessary conditions are extant, the lessons learned from the Guardrail program suggest several important characteristics that will affect the schedule performance of a program. First, system requirements should be developed through dialogue with the technical experts (both government and contractor).

This will tend to facilitate optimization of schedule through the systematic analysis of cost, schedule, and technical performance tradeoffs. As a result, requirements with minimal benefit, or value added, but large cost and schedule implications should be minimized.

A second characteristic follows from one of the conditions for a radically reduced cycle time program. Utilizing state-of-the-art, but sufficiently mature technology, discipline must be exercised in the development process to avoid design decisions that will require significant engineering development. A third characteristic will facilitate successive pre-planned product improvements and the potential to continually upgrade the system's capabilities with controlled schedule implications as the technology evolves. This is the use of open architecture as it was successfully demonstrated in the Guardrail program. Interrelated with the use of open architecture and the use of mature technology is the maximization of the use of COTS technology. Assuming the precondition for a high level of COTS exists, maximum utilization in design decisions will tend to positively affect schedule. However, it should be noted that COTS may also result in increased integration complexities. Therefore, design decisions must optimize the use of COTS in light of other variables.

"The Aerial Common Sensor...is a system that stands on the shoulders of giants when one views its extraordinary

A fifth characteristic involves the prime contractor being relegated full responsibility for system integration. As GR/CS began to deviate from this pattern there were adverse schedule implications. Integration is facilitated when responsibility is not diffused among multiple contractors and multiple government program offices.

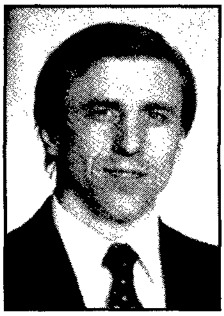
A sixth characteristic of an effective quick reaction capability program is interrelated with the first and the fifth characteristics. Based on the lessons learned from Guardrail is the selection of a prime contractor with continuity and depth in the system specific base of expertise. Without this the resultant learning curves are such that the program schedule will be adversely affected. Furthermore, without this depth of expertise, the potential for effectively setting requirements through dialogue is greatly diminished. Similarly, the potential for effective integration is also diminished.

Clearly, other characteristics of effective radically reduced cycle time programs exist. The characteristics outlined here have been drawn from the lessons learned from the Guardrail program. Other characteristics of such programs should be the subject of future research.

CONCLUSION

The historical development of the Guardrail program summarized in this case suggests that this evolution of advanced airborne communications and electronic intelligence systems represented one of the most successful defense systems developed during the last third of the twentieth century. Based on measures of program cost, schedule, and technical performance, the sequence of Guardrail systems was exceptional. The Guardrail systems provided commanders in the field with critical information during the Cold War, Desert Storm, and the conflict in Central Europe.

As the program proceeds in the twenty-first century, the COMINT and ELINT capabilities will be adjoined with imagery intelligence (IMINT) and measurement signature intelligence (MASINT) capabilities. This will be the next step in the relentless succession of Guardrail systems and it will be called the Aerial Common Sensor. The Aerial Common Sensor is scheduled to be deployed in 2010, and it is a system that stands on the shoulders of giants when one views its extraordinary technological heritage.



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LETTER TO THE EDITOR

The fall 2002 issue of the *Acquisition Review Quarterly* (*ARQ*) journal contained some very interesting articles. The one, which got most of my attention, is entitled "Using Options to Manage Dynamic Uncertainty in Acquisition Projects."

The authors make the following statement in their article. "But the processes, methods and tools for developing flexible strategic plans and adapting to changes have not been operationalized adequately to be applied to management of dynamic project uncertainty. Project planning, risk management, and other management decision-making theories also do not provide operational processes to proactively use flexibility to manage project uncertainty (Ceylan & Ford, 2002, p. 248).

Although I disagree with this statement, I tried to ascertain if there was really anything new in this presentation. However, I could not find anything new as the article was really a description of what systems engineering should do if properly implemented. Broadly defined, system engineering is not only flexible, but "the effective application of scientific and engineering efforts to transform an operational need into a defined system configuration through the top-down iterative process of requirements definition, functional analysis, synthesis, optimization, design, test, and evaluation" (Blanchard, 1991, p. 12).

In addition, system engineering can be broken down into four major steps as follows: A *top-down* approach, a *life-cycle* orientation, a better and complete effort regarding initial *identification of system requirements,* and an *interdisciplinary* approach through design and development (Blanchard, 1991, p. 13).

Starting with system design, any number of design proposals or alternatives may be considered, with several contracts competing for the most promising. Ample clauses protect the government's right to design data regardless of the termination of some of the design efforts. This data may contain alternatives for components which may result in development contracts to reduce risk.

One of the elements of the design evaluation process is the evaluation of risk and uncertainty. These terms tend to be used interchangeably, but "*risk* actually implies the availability of discrete data in the form of a probability distribution around a certain parameter. *Uncertainty* implies a situation that may be probabilistic in nature, but one that is not supported by discrete data" (Blanchard, 1991, p. 51). The aspects of risk and uncertainty must be incorporated in the part of systems engineering called the Program Risk Management Plan, which is a part of the overall Systems Engineering Management Plan.

The use of options in the acquisition field has been around a long time. Most research and development contracts provide for options to change the direction of the effort, increase funding, and extend completion, as well as a unilateral right of the government to terminate the effort.

As noted in the *ARQ* article, uncertainty is difficult to program, however it has been a recognized part of program management for many decades and highlighted during the 1970s by Dr. John S. Foster Jr., (then Director of Defense Research and Engineering, Department of Defense), who called the problem "unk-unks" or "unknown unknowns." Each program manager on the Defense Acquisition Review Council (DSARC) at that time was questioned about unknown-unknowns, with much discussion of statistical probability theory, financial provisions, and alternatives. However the best of theory could not provide for example the aftermath of September 11, 2001, the impact of action in Iraq, the oil problems generated by strikes in Venezuela, the Stevedore strike in California. It is however the major job of a program manager to manage uncertainty and that is the real test of his/her management skills. The flexibility and tools provided by system engineering which include evaluation of uncertainties, a comprehensive Work Break Down Structure (WBS), and a constant program review process provides the vehicle for minimizing the difficulties caused by uncertainty.

Most Program Managers hold a *rainy day* fund, and it would be great to hedge against all bets, but the best of option theory will not forecast or protect against uncertainties such as labor unrest, subcontractor bankruptcy, acts of God (Earthquakes, hurricanes, floods, and fire). Is there a statistical probability that one or more of these will occur and impact an ongoing system acquisition? Yes there is and it is calculable, but the probability is so large most PMs do not insure their programs against it, any more than the government provides knowing contingency funding or funds overruns before they occur. *Options* which are defined in the Merriam-Webster's Collegiate® Dictionary (1994) as the power or right to choose: freedom of choice, a privilege of demanding fulfillment of a contract on any day within a specified time, and a contract conveying a right to buy or sell designated securities, commodities, or property interest at a specified price during a stipulated period (p. 817), as follows and are expensive insurance, as any right under a contract costs money.

Also noted in the article, the use of options is not new. They may be contractual, part of the program plan or in the head of the program manager, and it is doubtful if any theory can aide in the management of uncertainty, given the dynamics of the environment in which we develop new systems, whether in industry or in government. The major players in system acquisition are: the contractor and staff, the program manager and staff, the Service of the program manager and staff, the Office of the Secretary of Defense and staff, the Congressional Committees and their staffs, and various subcontractors. With that much uncertainty created with that many participants, the following is considered appropriate "Consider now a participant in a social exchange economy.... Each participant attempts to maximize a function of which he does mot control all variables.... One would be mistaken to believe that [this kind of problem] can be obviated by a mere recourse to the devices of the theory of probability. Every participant can determine the variables which describe his own actions but not those of others. Nevertheless those 'alien' variables cannot, from his point of view, be described by statistical assumption" (Von Neumann & Morgenstern, 1994, pp. 9-11).

There are several classic programs where options were used quite successfully, but in different environments, different priorities, different funding structure, different timing, different political environment, different technologies, and different complexities. The F111B, Polaris/Poseidon, the nuclear submarine program; the Joint Aircraft Engine development, the development of solar energy; and from long ago the Manhattan project are examples. Trying to model uncertainty is like trying to model the movement of the stern of an aircraft carrier in heavy seas.

In closing, as a famous program manager said to other junior PMs: *"You have got to keep your options open."*

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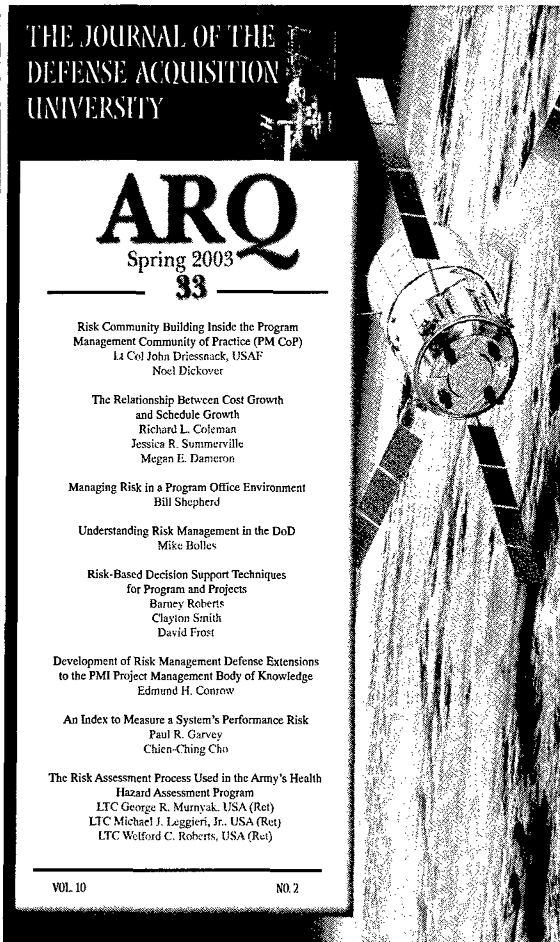

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The AT&L PM Cop is calling for papers on the "Essential Program Management Models and Enduring Principles: What Every Weapons Acquisition PM Should Understand." Selected papers will run the gamut of the weapons system acquisition disciplines, but essential pieces will fall into the categories of people, processes, products, and politics. The papers should reflect theoretical constructs that have critically passed the test of time, should include such essential frameworks as Performance Measurements and Integrated Product and Process Development (IPPD), must include a description of the model, examples of its successful application, and the *takeaway* from real experience.

Two-page abstracts are due December 31, 2003. Papers will be presented in a special track of panels at the June 2003 DAU Alumni Association conference at Fort Belvoir, VA. All selected conference papers will be WEB published on the PM Cop Web site. Seven outstanding papers will be part of the special Summer 2004 edition of the *ARQ*. Further details about the "Essential Models" effort can be found at http://pmcop.dau.mil/essentialmodels.

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We welcome submissions from anyone involved in the defense acquisition process. Defense acquisition is defined as the conceptualization, initiation, design, development, testing, contracting, production, deployment, logistic support, modification, and disposal of weapons and other systems, supplies, or services needed by the Defense Department, or intended for use to support military missions.

RESEARCH ARTICLES

Manuscripts should reflect research or empirically supported experience in one or more of the aforementioned areas of acquisition. Research, lessons learned or tutorial articles should not exceed 4,500 words. Opinion articles should be limited to 1,500 words.

Research articles are characterized by a systematic inquiry into a subject to discover/revise facts or theories.

MANUSCRIPT SECTIONS

A brief abstract provides a comprehensive summary of the article and must accompany your submission. Abstracts give readers the opportunity to quickly review an articles' content and also allow information services to index and retrieve articles.

The introduction, which should not be labeled, opens the body of the paper and states the problem being studied and the rationale for the research undertaken.

The methods section should include a detailed methodology that clearly describes work performed. Although it is appropriate to refer to previous publications in this section, the author should provide enough information so that the experienced reader need not read earlier works to gain an understanding of the methodology.

The results section should concisely summarize findings of the research and follow the train of thought established in the methods section. This section should not refer to previous publications, but should be devoted solely to the current findings of the author.

The discussion section should emphasize the major findings of the study and its significance. Information presented in the aforementioned sections should not be repeated.

RESEARCH CONSIDERATIONS

Contributors should also consider the following questions in reviewing their research-based articles prior to submission:

- Is the research question significant?
- Are research instruments reliable and valid?
- Are outcomes measured in a way clearly related to the variables under study?
- Does the research design fully and unambiguously test the hypothesis?
- Did you build needed controls into the study?

Contributors of research-based submissions are also reminded they should share any materials and methodologies necessary to verify their conclusions.

CRITERIA FOR TUTORIALS

Tutorials should provide special instruction or knowledge relevant to an area of defense acquisition to be of benefit to the Department of Defense Acquisition, Technology and Logistics Workforce.

Topics for submission should rely on or be derived from observation or experiment, rather than theory. The submission should provide knowledge in a particular area for a particular purpose.

OPINION CRITERIA

Opinion articles should reflect judgments based on the special knowledge of the expert. Opinion articles should be based on observable phenomena and presented in a factual manner; that is, submissions should imply detachment. The observation and judgment should not reflect the author's personal feelings or thoughts. Nevertheless, an opinion piece should clearly express a fresh point of view, rather than negatively criticize the view of another previous author.

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Please send us a cover letter; biographical sketch for each author (not to exceed 70 words); head and shoulder print(s) or digitized photo(s) (saved at 300 pixels per inch, at least 3 X 2 inches, and as a TIFF file); prints of photos will be accepted and returned upon request, one copy of the printed manuscript; and any diskettes. These items should be sturdily packaged and mailed to: Department of Defense, Defense Acquisition University, Attn: DAU Press (*ARQ Managing Editor*), Suite 3, 9820 Belvoir Road, Fort Belvoir, VA 22060-5565.

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Contributors may direct their questions to the Managing Editor, *ARQ*, at the address shown above, or by calling (703) 805-3801 (fax: (703) 805-2917), or via the Internet at norene.fagan-blanch@dau.mil.

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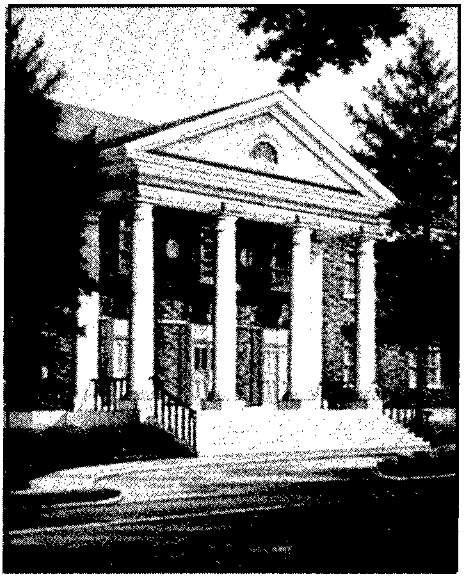

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