DEFENSE AR JOURNAL

Defense Acquisition Research Journal
A Publication of the Defense Acquisition University

Understanding the Nuts and Bolts of Acquiring Services

Doing More without More

2012 Research Paper Competition

Presented on behalf of DAU by:

DAU
Defense Acquisition University

April 2012 Vol. 19 No. 2
ISSUE 62

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2012**	2. REPORT TYPE	3. DATES COVERED **00-00-2012 to 00-00-2012**
4. TITLE AND SUBTITLE **Understanding The Nuts And Bolts Of Acquiring Services**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defense Acquisition University Press,Fort Belvoir ,VA,22060**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES **Defense Acquisition Research Journal, April 2012, Vol 19, No 2, Issue 62**		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**222**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Doing More without More

2012 Research Paper Competition

ISSN 2156-8391 (print) ISSN 2156-8405 (online)

The *Defense Acquisition Research Journal,* formerly the *Defense Acquisition Review Journal*, is published quarterly by the Defense Acquisition University (DAU) Press. Postage is paid at the U.S. Postal facility, Fort Belvoir, VA, and at additional U.S. Postal facilities. Postmaster, send address changes to: Editor, *Defense Acquisition Research Journal,* DAU Press, 9820 Belvoir Road, Suite 3, Fort Belvoir, VA 22060-5565. For free copies, mail written requests with an original signature to the above address using the subscription form provided in this journal. Some photos appearing in this publication may be digitally enhanced.

DEFENSE ARJ JOURNAL

A Publication of the Defense Acquisition University

The *Defense Acquisition Research Journal (ARJ)* is a scholarly peer-reviewed journal published by the Defense Acquisition University (DAU). All submissions receive a blind review to ensure impartial evaluation.

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Supply Chain Management & Strategic Acquisition Course Research Paper: The Case for Professional Pay in the Army Acquisition Corps

COL John Lemondes, USA

This article assesses the opinions of Army Acquisition Workforce members who will serve in or are competing for program manager/command, or other leadership positions within the Army Acquisition Corps (AAC) on the subject of professional pay. A survey by the author determined: (a) whether professional pay would reduce loss of Army officers at the LTC/20-year point, with a lesser emphasis on COL/26-year point; (b) whether it would incentivize career civilians to compete for board select product/program management positions; and (c) whether it would it help keep both labor pools in the AAC past retirement eligibility. The author concludes that professional pay is an attractive incentive to further professionalize the AAC, and also formalize its professionalization throughout the Army.

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From the Chairman and Executive Editor

This issue is devoted to the annual Hirsch Research Paper Competition sponsored by our partner organization, the Defense Acquisition University Alumni Association (DAUAA, www.dauaa.org). For 2012, the competition was entitled "Doing More Without More: Government and Industry Imperatives for Achieving Acquisition Efficiencies." Sharp-eyed readers will note that "do more with more" was the direction given to defense acquisition professionals in 2010 by Dr. Ashton Carter, then-Undersecretary of Defense for Acquisition, Technology and Logistics, as he unveiled the department's Better Buying Power Initiatives (BBPI).[1]

As part of the ongoing effort to better support BBPI, DAU has developed a list of suggested research topics, based on inputs from subject matter experts across defense acquisition sectors. This research agenda is intended to make researchers aware of the topics that are, or should be, of particular concern to the broader defense acquisition community throughout the government, academic, and industrial sectors. In each issue of the *Defense ARJ*, we shall excerpt a portion of this agenda. The full agenda, which is updated regularly, may be found at: http://www.dau.mil/research/Pages/researchareas.aspx

The papers submitted for the 2012 competition were selected from a strong field of candidates, and many of the other papers will be published in upcoming issues. First prize went to "Enhancing Cost Realism through Risk-Driven Contracting" by Sean Dorey, Josef Oehmen, and Ricardo Valerdi, who propose risk-driven contract incentives to hold contractors and the government accountable for the realism of system development proposals. Second prize went to "Managing Life-Cycle Information of Aircraft Components" by Geraldo Ferrer and Aruna U. Apte, who describe how modern logistics management systems like Item-Unique Identification (IUID) and Radio-Frequency Identification (RFID) can increase operational availability. Third prize went to "RAH-66

Comanche–The Self-Inflicted Termination" by Julien Demotes-Mainard (who, we should note, is the first international author to win a DAUAA research paper award), which ascribes the demise of the Army's premier scout/attack helicopter program to a decrease in political support. We congratulate all the authors on their selection for the prestigious DAUAA prizes.

The Association of the United States Army also awards prizes, one of which went to John Lemondes' paper "The Case for Professional Pay in the Army Acquisition Corps," which he wrote while at the International College of the Armed Forces, which forms part of the National Defense University. We are pleased to publish it as the *Defense ARJ*'s first online article. (We note here that the new contributors' guidelines now allow for longer articles—up to 10,000 words—to be submitted. Longer articles may appear in the online edition of the *Defense ARJ*, with the abstract and keywords appearing in the print edition.)

Rounding out this issue is Roy Wood's review of *Rearming for the Cold War, 1945–1960* by Elliott Converse III, a new publication by the Historical Office of the Office of the Secretary of Defense that explores the roots of the defense acquisition organization and processes we use today.

Dr. Larrie D. Ferreiro
Executive Editor
Defense ARJ

[1]Department of Defense. (2010, June 28). Better Buying Power: Mandate for Restoring Affordability and Productivity in Defense Spending [Memorandum]. Washington, DC: Office of the Under Secretary of Defense for Acquisition, Technology and Logistics.

DAU Center for Defense Acquisition Research

Research Agenda 2012-2013

The Defense Acquisition Research Agenda is intended to make researchers aware of the topics that are, or should be, of particular concern to the broader defense acquisition community throughout the government, academic, and industrial sectors. The purpose of conducting research in these areas is to provide solid, empirically based findings to create a broad body of knowledge that can inform the development of policies, procedures, and processes in defense acquisition, and to help shape the thought leadership for the acquisition community.

Each issue of the Defense ARJ will include a different selection of research topics from the overall agenda, which is at: *http://www.dau.mil/research/Pages/researchareas.aspx*

Measuring the effects of competition

- What means are there (or can be developed) to measure the effect on defense acquisition costs of maintaining an industrial base in various sectors?
- What means are there (or can be developed) of measuring the effect of utilizing defense industrial infrastructure for commercial manufacture, in particular in growth industries? In other words, can we measure the effect of using defense manufacturing to expand the buyer base?
- What means are there (or can be developed) to determine the degree of openness that exists in competitive awards?
- What are the different effects of the two best value source selection processes (tradeoff vs. lowest price technically acceptable) on program cost, schedule, and performance?

Strategic competition

- Is there evidence that competition between system portfolios is an effective means of controlling price and costs?
- Does lack of competition automatically mean higher prices? For example, is there evidence that sole source can result in lower overall administrative costs at both the government and industry levels, to the effect of lowering total costs?
- What are long-term historical trends for competition guidance and practice in defense acquisition policies and practices?
- To what extent are contracts being awarded non-competitively by congressional mandate, for policy interest reasons? What is the effect on contract price and performance?
- What means are there (or can be developed) to determine the degree to which competitive program costs are negatively affected by laws and regulations such as the Berry Amendment, Buy-America Acts, etc.)?

DEFENSE ***ACQUISITION RESEARCH*** JOURNAL

ISSUE **62** APRIL 2012 VOL. 19 NO. 2

Keywords: *Risk Management, Cost Estimation, Probability, Contract Incentives, Cost Realism*

Enhancing Cost Realism through Risk-Driven Contracting: *Designing Incentive Fees Based on Probabilistic Cost Estimates*

Maj Sean P. Dorey, USAF, Josef Oehmen, and Ricardo Valerdi

A risk-driven contract structure is proposed to enhance the cost realism of competitive proposals for the Engineering and Manufacturing Development (EMD) phase of the acquisition life cycle. The authors employ an economic theory framework to discuss how cost-plus contracts typically used during this phase have inadvertently reinforced the sources of contractor and government optimism bias. By mapping probabilistic cost estimates to profit distributions, risk-driven contracts offer a structured method to expose contractors to more cost risk during EMD. Holding contractors accountable for their cost estimates and cost performance should enhance the realism of cost proposals, limit the government's ability to commit to too many programs, and reduce the cost growth that continues to plague the defense acquisition system.

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The Government Accountability Office (GAO) reported a combined $296 billion in cost growth on the Department of Defense's 96 major acquisition programs in fiscal year (FY) 2008. Sixty-nine percent (64 of the 96 programs) experienced cost growth, demonstrating that the cost growth is not just limited to a few programs. In addition, 42 percent (40 programs) reported at least 25 percent unit cost growth, demonstrating that the bulk of the growth is not limited to a few programs either. Finally, 75 percent (69 programs) experienced increases in research, development, test, and evaluation (RDT&E) costs, demonstrating that problems often start early in the acquisition life cycle (GAO, 2009, p. 2). This last statistic is particularly important to this research since risk-driven contracts are targeted at improving cost realism for system development efforts.

To put this $296 billion cost growth into perspective, consider that the FY 2012 President's Budget Request is $671 billion (including funding for the operations in Afghanistan and Iraq), with $204 billion allocated to acquisitions ($128 billion for procurement and $76 billion for RDT&E) (DoD, 2011, p. 8-3). Thus, if DoD still wants these 96 weapon systems, it must cover an unfunded liability greater than its annual acquisitions budget. This daunting task is compounded by the current state of the economy and the resulting fiscal pressures. Defense Secretary Robert M. Gates (2011) remarked:

> This department simply cannot risk continuing down the same path–where our investment priorities, bureaucratic habits, and lax attitudes towards costs are increasingly divorced from the real threats of today, the growing perils of tomorrow, and the nation's grim financial outlook.

In support of enhancing cost realism, this article is organized into three parts: (a) a brief review of the difference between cost growth and cost overruns, (b) a discussion of the primary reasons for unrealistic cost estimates, and (c) a detailed demonstration of risk-driven contracts.

Cost Growth vs. Cost Overruns

Cost growth implies an increase in the life-cycle cost estimate, which may or may not affect the cost performance of the current contract. For example, a choice to use a specific material during system development could lead to increased procurement costs without necessarily increasing the development costs. On the other hand, a cost overrun results when a program exceeds the target cost of its contract, which usually leads to life-cycle cost growth despite the prospect for future efficiencies.

When target costs are unrealistic, overruns do not necessarily indicate excessive expenditures (Cummins, 1977, p. 179). Despite the reasons for overruns, they are almost always counterproductive. First, they often lead to funding instability within a portfolio, which in turn leads to adjustments between programs (damaging healthy programs to rescue sick ones), reductions in requirements or procurement quantities, or extensions to schedules (GAO, 2008, p. 11). Second, overruns can damage public perception and, as a result, diminish congressional support and risk eventual cancellation (Cummins, 1977, p. 179). And third, overruns can be perceived as a managerial failure and lead to drastic personnel replacements in the government and contractor program offices (Scherer, 1964, pp. 275–276).

Reasons for Unrealistic Cost Estimates

Cost estimates can be unrealistic for a multitude of reasons, which include an overemphasis on the technical cost drivers, optimism bias, and misaligned contract incentives.

Overemphasis on Technical Cost Drivers

While room for improvement always exists, today's professional cost estimators have an abundance of tools from which to leverage best practices. Sophisticated cost-estimation guides have been published by the Army, Navy, Air Force, National Aeronautics and Space Administration (NASA), GAO, RAND, International Society of Parametric Analysts/Society of Cost Estimating and Analysis (ISPA/SCEA), and the Space Systems Cost Analysis Group (SSCAG). Also available are extensive articles, conferences, and training and certification opportunities from professional societies like ISPA, SCEA, SSCAG, and the United Kingdom's Society of Cost Analysis and Forecasting (SCAF). In addition, Garvey (2000) authored the definitive textbook on cost estimation wherein he describes the principal methods for addressing cost uncertainty. Finally, a vast array of software tools can be used to construct cost estimates, such as the Automated Cost Estimating Integrated Tools (ACEIT), Crystal Ball, @RISK, PRICE, System Evaluation and Estimation of Resources (SEER), NASA/Air Force Cost Model (NAFCOM), Constructive Cost Model (COCOMO) II, and Constructive

Systems Engineering Cost Model (COSYSMO). In an unbiased world, subject matter experts applying these tools and best practices would generate more accurate and reliable cost estimates. But the problem is not a lack of guidance or tools—it is that the cost estimation community usually considers only the technical variables contributing to cost risk.

Optimism Bias

An understated cause of cost overruns is optimism bias, which is defined as the tendency for people to be overconfident in their predictions (Valerdi & Blackburn, 2009). A common form of optimism bias is optimistic technical estimates, which range from the weight of a hardware component to the number of software lines of code. Perhaps the most difficult and subjective part of cost estimation is eliciting these estimates from technical experts. Unfortunately, it has been shown that most experts are overly optimistic in providing both their most likely and worst-case estimates (Russo & Schoemaker, 1992). Hubbard (2010, pp. 57–77), building on the original research of Brier (1950), provides a practical technique to "calibrate" experts to provide better estimates when confronted with uncertainty.

A second, and equally damaging, form of optimism bias is optimistic management estimates by both contractors and the government. The contractor's optimism bias is caused by pressures to win competitions. William M. Allen, Boeing's president in 1964, admitted, "I can think of a lot of programs in the Boeing Company where, if the estimate had been realistic, you wouldn't have had the program. And that is the truth" (Butts & Linton, 2009, p. 36).

While two or more contractors are often funded during early technology development and prototyping efforts, the government typically only funds a single contractor during EMD due to prohibitively high system development costs. After several years of focused government investment, the incumbent contractor normally develops a significant technical advantage. Thus, the government's options are greatly limited since the prospect of reattempted competition is dubious at best. As a result, the contractor that wins the competitive EMD downselection usually monopolizes the production and sustainment efforts as well. With so much long-term revenue and profit on the line, competition to win the EMD contract is intense. And since cost is a leading variable in the government's source selection, there is a strong motivation to provide the lowest cost proposal.

The government's optimism bias is caused by the Services' desire to secure funding for new programs and sustain funding for existing ones. To maintain the appearance of affordability, cost estimates that fit within authorized budgets are at least tacitly encouraged (Williamson, 1967, p. 229; GAO, 2008, pp. 20-21). In addition, U.S. Senators and Representatives often contribute to the government's optimism bias by supporting programs with poor business cases when the funding is allocated to their constituents.

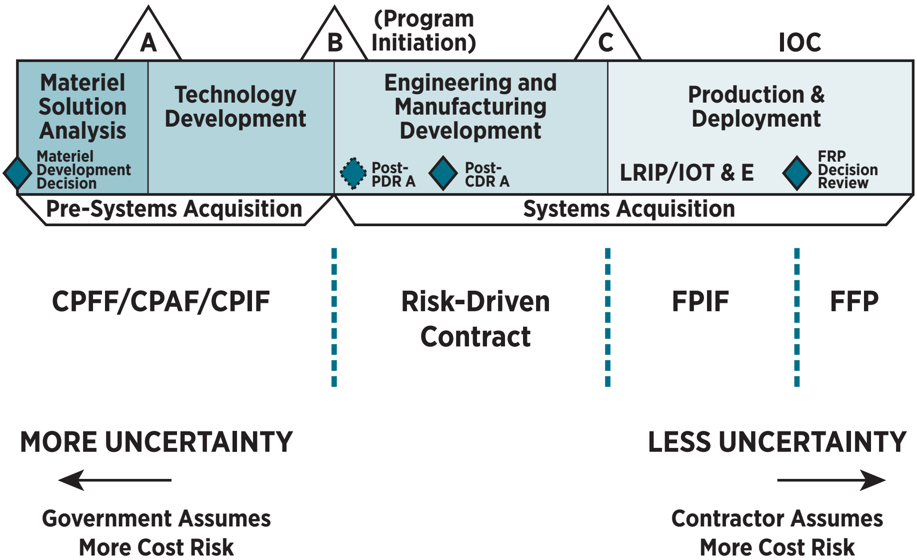
Misaligned Contract Incentives

While strong leadership and accountability may help reduce optimism bias amongst stakeholders, properly implemented contract incentives are an even stronger antidote. Figure 1 organizes the most prevalent contract types by their degree of risk sharing and typical use throughout the acquisition life cycle. Cost Plus Fixed Fee (CPFF) and Firm Fixed Price (FFP) contracts represent two polar extremes with no risk sharing. The government assumes all cost risk in a CPFF contract, and the contractor assumes all cost risk in an FFP contract. Cost Plus Incentive Fee (CPIF) and Fixed Price Incentive Firm Target (FPIF) contracts offer a middle ground with risk sharing by both the government and contractor. Of these two incentive contracts, only FPIF contracts expose contractors to a potential loss, but as with FFP contracts, maximum losses are not constrained. Theoretically, a contractor can be forced into bankruptcy in attempting to fulfill the requirements of an FFP contract. However, with the dwindling defense industrial base (Aerospace Industries Association, 2009), it is not in the government's best interest to force a contractor out of business. In addition, contractors are likely to mount protracted legal battles to protect their interests, which are counterproductive in delivering capability to the warfighter and a poor use of taxpayer resources.

On the other hand, a contractor's maximum liability for overrunning a typical CPIF contract is no profit. While their short-term stock prices may be impacted, at least four reasons can be set forth to explain why contractors still benefit when they receive no profit (Fox, 1974, pp. 242–243):

- Scientists and engineers are gainfully employed (or hired) and available for future programs.
- Technology competency is accrued, which improves their market position for future government and commercial business.
- Facilities and equipment are maintained and often upgraded at the government's expense.
- Overhead expenses for other programs (and potential new programs) are slightly reduced by contributions to the overhead pool.

FIGURE 1. RECOMMENDED CONTRACT TYPES FOR EACH ACQUISITION PHASE



Note. *IOC = Initial Operational Capability; PDR = Preliminary Design Review; LRIP = Low Rate Initial Production; IOT&E = Initial Operational Test and Evaluation; FRP = Full Rate Production; CPFF = Cost Plus Fixed Fee; CPAF = Cost Plus Award Fee; CPIF = Cost Plus Incentive Fee; FPIF = Fixed Price Contract with Incentive Firm Target; FFP = Firm Fixed Price. Adapted from Operation of the Defense Acquisition System, DoD Instruction 5000.02, 2008, p. 12.*

Properly designed incentive contracts address classic moral hazard and adverse selection problems (McAfee & McMillan, 1986, p. 326). Moral hazard is the propensity to act differently when insulated from the risk of a loss. Thus, moral hazard encompasses the propensity for contractors to underestimate competitive program costs and carry excess organizational slack during contract execution when not exposed to a potential loss. Organizational slack is characterized by inefficiently high operating and investment expenses (Williamson, 1967, pp. 224–226). Operating expenses can be reduced through the adoption of lean practices if risk sharing is high enough to overcome the cultural barriers to change. In addition, contractors are likely to allocate their best people to the contracts with the largest potential losses, which can also help reduce operating costs. Conversely, less risk sharing is likely to increase organizational slack in favor of more investment expenses. For example, Scherer (1964, p. 263) identifies the government's source

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selection emphasis on the availability of skilled manpower as an encouraging factor in contractors maintaining their workforces at inefficiently high levels.

Adverse selection deals with the government's imperfect knowledge of the expected cost of each contractor. Williamson (1967, p. 230) boldly states, "It is unquestionably true that the government suffers from an information disadvantage." Indeed, contractors benefit from locally calibrated parametric cost models, employ the technicians and engineers who will be working on the contract, and have close relationships with key suppliers.

If the government had perfect information (and was free from contractors' moral hazard), it would award a CPFF contract to what it knew to be the lowest cost contractor to avoid the risk premium of incentive contracts (Samuelson, 1986, p. 1,539). However, since the government does not have perfect information and cannot avoid contractors' moral hazard, economists reject using cost-plus contracts for competitive source selections (McAfee & McMillan, 1986, p. 327). Instead, economists advocate contracts that expose contractors to a potential loss to solicit their unbiased cost estimates, but for system development efforts with high uncertainty, potential contractor losses need to be appropriately limited. Otherwise, to avoid the extremely high cost risks of fixed-price arrangements, contractors may choose not to bid, which would in turn reduce the competition essential to both guarding against overestimation bias and producing viable warfighter options.

As with the cyclic nature of most acquisition reforms, DoD has oscillated back and forth between its preference for cost-plus and fixed-price contracts. Cancian (1995, pp. 195-196) traced the history of this oscillation over the past several decades. In the 1950s, he noted that cost-plus contracts were the norm. The resulting huge overruns led to a preference for fixed-price Total Package Procurement contracts in the 1960s. When this practice failed due to the high risks contractors were forced to assume, cost-plus contracts resumed their prevalence in the 1970s. Amid perceived procurement "scandals," DoD again shifted its preference back to fixed-price contracts in the 1980s. Of course this policy failed again for the same reasons, bringing the defense acquisition process to its current phase where cost-plus contracts are again dominant.

It appears the pendulum may be swinging back to fixed-price contracts with recent directives published by a former Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]) (Carter, 2010, p. 6). However, the guidance on using FPIF contracts focuses on early production contracts (just after Milestone C in Figure 1.). This guidance is a step in the right direction away from the subjective Cost Plus Award Fee (CPAF) contracts that have recently become common during early production, but does not address the misaligned incentive structures typically used during system development when the cost uncertainty is even higher.

Risk-Driven Contracts

Rather than continuing to oscillate back and forth between cost-plus and fixed-price contracts, DoD could benefit from embracing a hybrid, risk-driven contract type for system development. As discussed above, FPIF contracts are inappropriate since they do not constrain the maximum loss potential for contractors. CPIF contracts could be used to expose contractors to a limited loss potential by extending the sharing line into the negative fee region, but in practice this is rarely done since negotiating an arbitrary maximum cost point is extremely difficult. For example, if a contractor submits a point cost estimate of $100 million with no further information, how should the maximum cost point be determined? This process is difficult enough when the minimum fee is positive. Negotiating an arbitrary maximum cost point when a $20 million loss is at stake could be unworkable.

Notional Probabilistic Cost Estimates

By taking advantage of modern probabilistic cost estimates, risk-driven contracts provide a structured method to impose a limited loss potential on contractors. Experience has shown that defense acquisition program cost estimates are often best modeled by the lognormal probability distribution because its right skew accurately reflects the disproportionate chance and magnitude of cost overruns (Department of the Air Force, 2007, p. 96).

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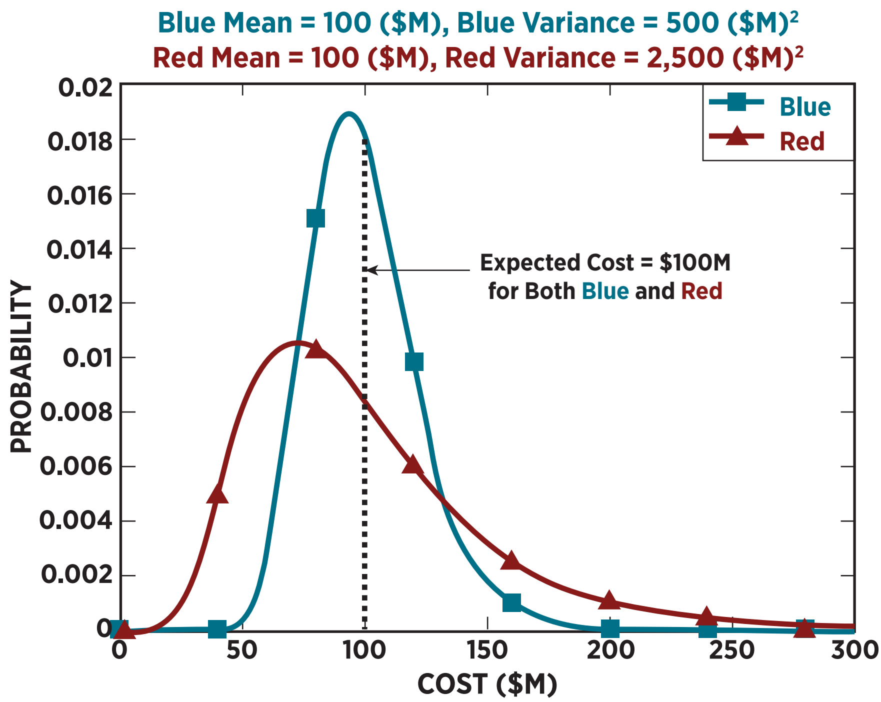
FIGURE 2. NOTIONAL PROBABILITY DISTRIBUTION FUNCTIONS



Two lognormal probability distributions will be used throughout this paper to describe the risk-driven contract structure. Figure 2 shows the probability distribution functions (PDF) of "blue" and "red" probabilistic cost estimates with the same mean but difference variances. The blue cost estimate represents a notional Low-Rate Initial Production (LRIP) proposal, and the red cost estimate represents a notional EMD proposal. Note that the red estimate has both a higher cost risk and opportunity than the blue estimate, as shown by its longer right and left-hand tails, respectively. With less of the design locked down, decisions made on the red EMD program often have a larger marginal cost impact than the relatively minor decisions still pending on the blue LRIP program.

FIGURE 3. NOTIONAL CUMULATIVE DISTRIBUTION FUNCTIONS

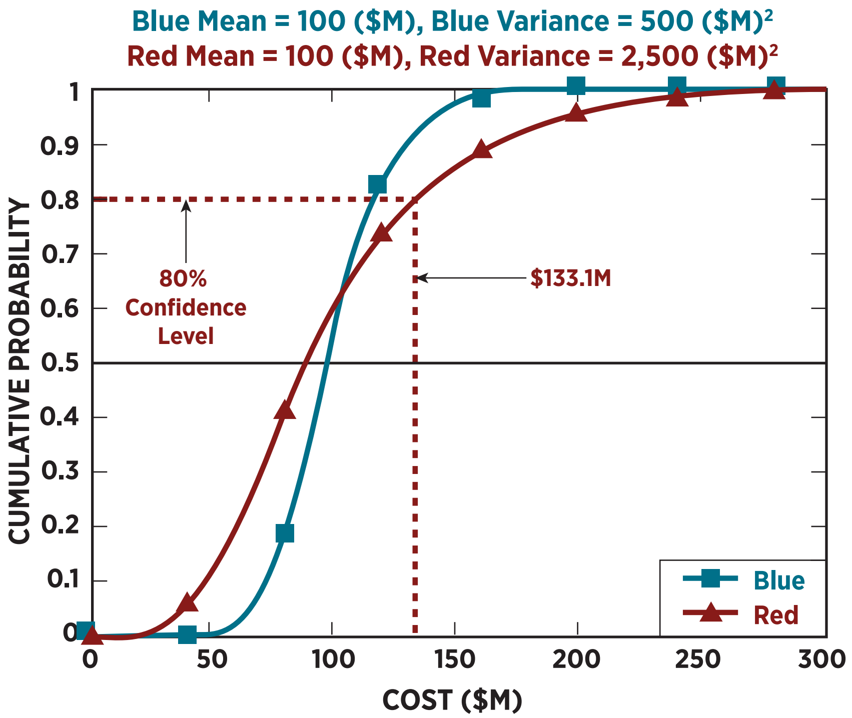


Figure 3 shows the corresponding cumulative probability distribution functions (CDF) which reveal the confidence level of each possible cost from the notional PDFs. For example, there is an 80 percent chance that the red program will cost $133.1 million or less. Table 1 lists selected confidence levels from Figure 3 that are used in this article. Finally, for the purposes of this discussion, the blue and red cost estimates are assumed to be accurate and unbiased. They bound the possible costs without the influence of any technical estimation errors or optimistic biases.

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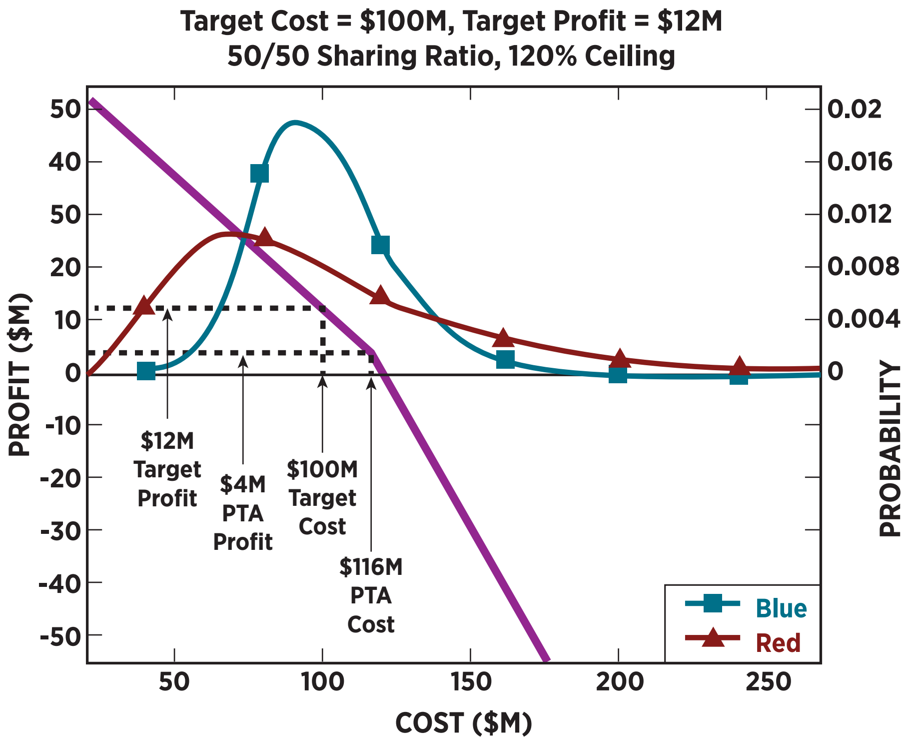
TABLE 1. SELECTED CONFIDENCE LEVELS FROM FIGURE 3

Cost ($M)	Confidence	
	Blue	Red
65.0		25%
84.1	25%	
89.4		50%
97.6	50%	
100	54.4%	59.3%
117.5	80%	
120	82.5%	73.3%
133.1		80%
140.3	95%	
163.1	99%	
194.5		95%
268.4		99%

Fixed Price Incentive Firm Target Contract Structure

Before describing the risk-driven contract structure, the expected profits from an FPIF contract will be briefly outlined for comparison purposes. Consider the FPIF contract structure shown in Figure 4. The solid magenta profit sharing line is applied to both the blue and red cost estimates portrayed on the right "Probability" axis. The target cost is set to $100 million—the expected cost of both the blue and red programs. A $12 million target profit is set for illustrative purposes. Finally, a 50/50 sharing ratio and 120 percent ceiling are set in accordance with USD(AT&L)'s recommended point of departure (Carter, 2010, p. 6). The point of total assumption (PTA) cost and profit ($116 million and $4 million, respectively) are calculated based on the above variables.

FIGURE 4. FIXED PRICE INCENTIVE FIRM TARGET CONTRACT STRUCTURE



Note. PTA = Point of Total Assumption.

The expected profit of each program is determined by multiplying the profit at each cost by its corresponding probability and then summing all possibilities. Thus, the blue and red cost estimates are seen as weighting functions on the magenta sharing line. The net result is $10.9 million for the blue program and $7.5 million for the red program. Since the expected profits are different for each program, this contract structure is not universally applicable to all cost estimates. To match the expected profits for both cost estimates, a trial-and-error method adjusting the sharing ratios and ceiling percentages would be required.

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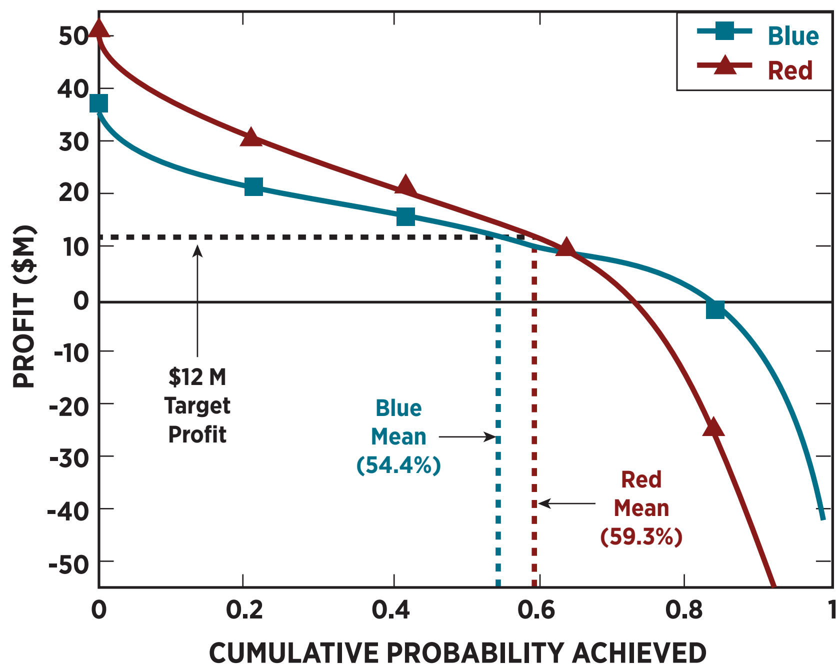
FIGURE 5. PROBABILITY DOMAIN REPRESENTATION OF FIGURE 4



Next, observing from Figure 3 that each cost has a corresponding confidence level, it is possible to display the profit sharing relationships in the probability domain, as shown in Figure 5. The blue and red cost estimates each have distinct profit sharing curves. As previously discussed, the red program is seen to have a higher profit opportunity, but also a much higher potential loss. Assuming the cost estimates accurately bound the possible costs (and setting the maximum costs to the 99 percent confidence levels), the maximum loss is $43.1 million for the blue program and $148.4 million for the red program. It must be noted, however, that there is only a 1 percent chance of incurring these maximum losses. At this point, it should be obvious that this FPIF contract structure favors the blue cost estimate. While contractors might agree to this FPIF contract for the blue program, it is highly unlikely they would expose themselves to a $148.4 million loss on the red program even when there is a $7.5 million expected profit.

Risk Aversion in Human Decision Making

Economists have studied the risk aversion propensity of contractors to sacrifice higher expected profit margins in order to minimize their share of potential losses when faced with uncertainty. Scherer (1964, p. 276) collected strong empirical evidence to support this violation of expected profit maximization theory whereby risk-neutral contractors would prefer the contract offering the highest expected profit despite its potential losses. In addition, Kahneman won the Nobel Prize in Economics for modeling the psychology of decision making under uncertainty. Working together with Tversky, Kahneman (1984) confirmed that it is human nature to be risk averse. Their findings support the conclusion that in general people are more likely to settle for a sure gain than gamble for a higher expected gain. For example, most people would rather settle for an $800 sure gain than bet on an 85 percent chance to win $1,000 (with a 15 percent chance to win nothing) even though the latter has the higher mathematical expectation of $850 (Kahneman & Tversky, 1984, p. 341).

Risk-Driven Contract Structure

It should be no surprise that the FPIF example cited previously favors the blue cost estimate, which is more representative of an LRIP program. In addition, the very large potential loss for the red program confirms why FPIF contracts are not typically appropriate for system development efforts during EMD. However, rather than settling for a cost-plus contract variant during EMD, government acquisition officials could benefit from considering a risk-driven contract.

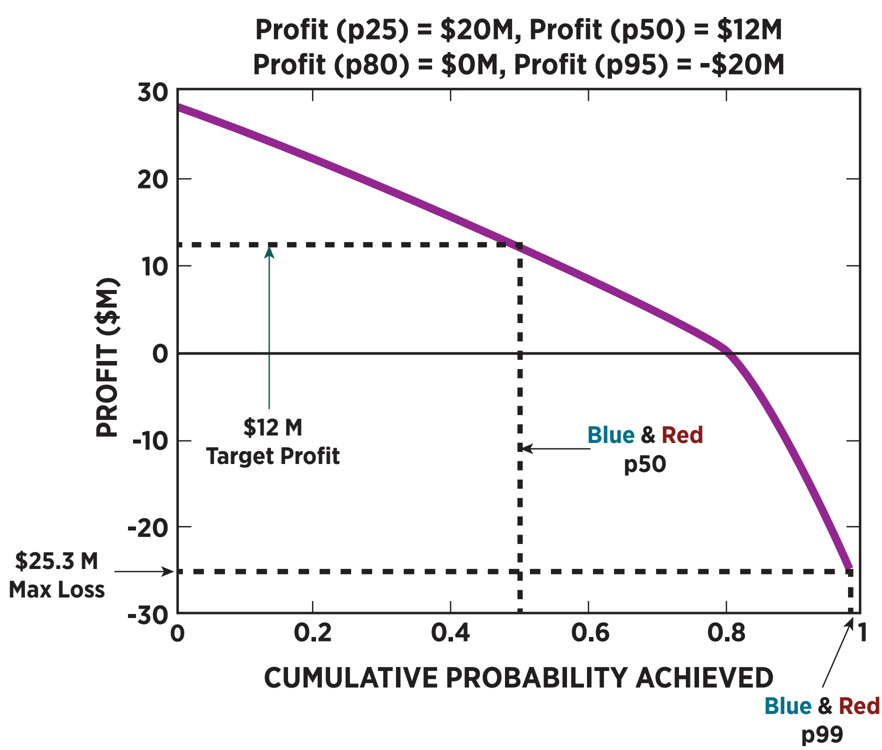
Unlike the FPIF contract structure, which draws sharing lines in the cost domain, the risk-driven contract structure starts in the probability domain, as shown in Figure 6. This illustrative contract is structured by setting four profit points:

- Profit (p25) = $20M
- Profit (p50) = $12M
- Profit (p80) = $0M
- Profit (p95) = -$20M

1

For example, the target profit is set to $12 million at both the blue and red 50 percent confidence levels. More importantly, notice how determining the zero and $20 million loss levels in the probability domain provides a structured approach to holding contractors accountable for overly optimistic cost estimates or poor cost performance. The sharing lines simply connect (or extend) the profit points, and are again magenta since they apply to both the blue and red cost estimates.

FIGURE 6. RISK-DRIVEN CONTRACT STRUCTURE

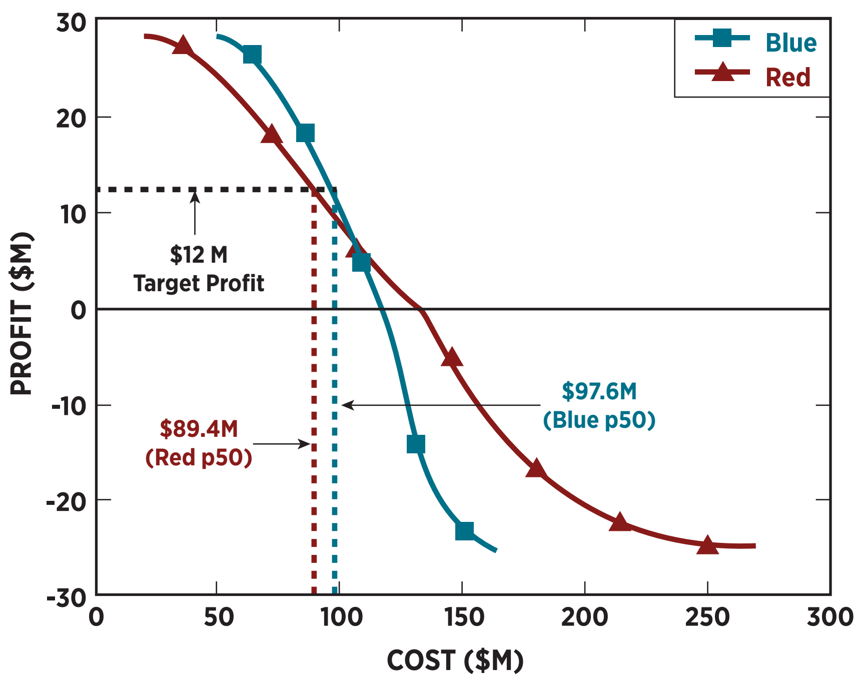


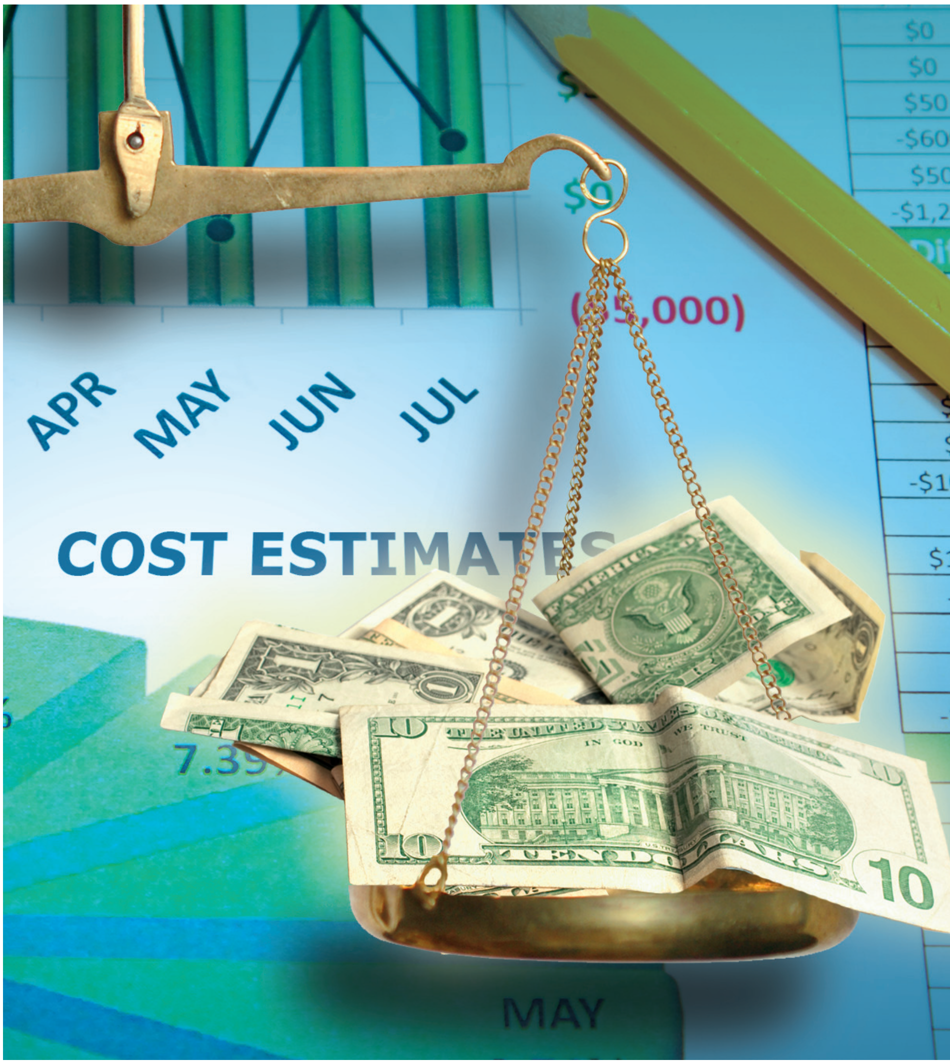
By determining profits in the probability domain, risk-driven contracts reward (or penalize) contractors equally for equivalent cost savings effort. For example, reducing costs from the 50 to 45 percent confidence level earns the same profit increase for both the blue and red programs. Thus, risk-driven contracts normalize the relative value of decisions made on programs with different cost uncertainties. This is contrasted with the FPIF contract structure where saving the same dollar amount on either the blue or red program always earns the same profit increase regardless of the amount of effort required to achieve the savings.

Under the risk-driven contract structure shown in Figure 6, the expected profit for both the blue and red programs is $9.5 million. Note that there is no need to adjust sharing ratios or ceiling percentages to achieve the same expected profit as described above for FPIF contracts. In this way, risk-driven contracts could provide a more universal point of departure for EMD contracts. Policymakers would simply have to determine a few profit points in the probability domain as outlined above.

Figure 6 also reveals the same maximum loss for both the blue and red programs. There is a one percent chance that either program might incur a $25.3 million loss. Further, there is only a 20 percent chance of incurring any loss. Again, while the goal is not to set any specific profit or loss policies, it should be noted how the risk-driven contract provides a method to more reasonably limit the potential losses of contractors engaging in risky development efforts. The objective is to set the loss probability and magnitude to the lowest possible levels that will counteract the previously described moral hazard and adverse selection problems.

FIGURE 7. COST DOMAIN REPRESENTATION OF FIGURE 6





It is also instructive to examine the risk-driven contract structure in the cost domain, as shown in Figure 7. The first major observation is the upper end of the red program's profit is now less than that of the blue program unlike the FPIF contract example shown in Figure 5. The government shares a larger portion of the red program contractor's upside profit in return for limiting its potential losses. In effect, the contractor trades slightly less profit opportunity for greatly reduced loss risk, which should be an acceptable trade for a risk-averse contractor. In fact, as shown in Table 2, the maximum profit on the red program has decreased from $51.6 million to $28.0 million while the maximum contractor loss has been reduced from $148.4 million to $25.3 million. In addition, the risk-driven contract offers the red program a higher expected profit, $9.5 million as compared to the $7.5 million offered by the FPIF contract. Thus, contractors should clearly favor similarly structured risk-driven contracts over the FPIF contracts for EMD efforts.

TABLE 2. COMPARISON OF FPIF AND RISK-DRIVEN CONTRACT PROFITS/LOSSES

	FPIF		Risk-Driven
	Blue	Red	Blue & Red
Expected Profit	$10.9M	$7.5M	$9.5M
Max Profit (p0)	$37.3M	$51.6M	$28.0M
Max Loss	$43.1M	$148.4M	$25.3M

A second major observation from Figure 7 is the flattening of the sharing curve as the cost uncertainty increases. Indeed, it is appropriate for the government to share a larger portion of the cost risk for requiring greater innovation. However, this natural flattening trend also leads to a potential drawback of the risk-driven contract. As the cost uncertainty increases, the government is forced to allocate more funding to the program. In the case of the red program, the government would have to allocate $243.1 million to cover its share of the contract to the 99 percent confidence level without violating the anti-deficiency laws (which require the government to budget to its full contract liability). The government's liability could be reduced to a more reasonable $174.5 million by agreeing to terminate the contract at the 95 percent confidence level. However, the contractor's maximum liability would also be reduced from $25.3 million to $20.0 million. Thus, care must be taken to maintain the contractor's liability at a sufficient level to still motivate unbiased cost estimates.

Risk-Driven Contract Scenario

The extra funding required to cover the upper end of the risk-driven contract value could be considered the usual cost of overruns. Rather than unknowingly starting a system development effort with an optimistic cost estimate and later dealing with an overrun, the risk-driven contract structure should bring more realism to the initial affordability assessment. For example, consider the following scenario: Two contractors bid $1.9 billion and $2.0 billion for a competitive cost-plus EMD contract. The government's independent cost estimate is $2.5 billion, so the government awards the $1.9 billion proposal and sets aside an additional $400 million for management reserve. However, 2 years into the 3-year contract, the winning contractor projects an estimate at completion of $3.0 billion. The government is left with two undesirable choices: cancel the program and lose the investment or scramble to find an additional $700 million to cover the overrun.

The scenario just described could be improved through risk-driven contracting. Being exposed to the risk of a loss, the contractors should provide more realistic cost proposals. Perhaps they bid expected costs of $3.0 billion and $3.2 billion. Even more, the cost proposals are probabilistic, giving the government much more visibility into the range of possible costs as opposed to the point estimates normally provided today. Given its $2.5 billion independent cost estimate, the government may be surprised by the high contractor cost estimates and needs to decide whether the weapon system is still worth the expected cost. However, in this case, the knowledge-based affordability assessment is made before the contract is started. And if the contract is still awarded, there is a much better chance it will be adequately funded.

Conclusion and Recommendations

Risk-driven contracts are aimed at reducing cost overruns during the EMD phase of the defense acquisition life cycle. Unlike the traditional cost-plus contracts typically used during this phase, risk-driven contracts offer a structured approach to impose a potential loss on contractors despite the higher technical uncertainty. By exposing contractors to more cost risk, risk-driven contracts should overcome the issues related to moral hazard and adverse selection, and thus motivate contractors to provide more realistic cost estimates and implement more cost control discipline during contract execution. Furthermore, unlike fixed-price contracts where losses are unconstrained, risk-driven contracts appropriately limit potential losses, so competition should not be unduly hindered.

Engineering Change Proposals

To make up for unrealistic initial estimates, contractors often count on ECPs to increase profit margins. Unfortunately, risk-driven contracts do not directly solve this dilemma. However, with increased exposure to losses on the base contract, contractors will likely:

- demand more clearly defined requirements and responsibly limit requirements creep;
- augment precontract planning tasks (such as securing vendor commitments and investing in technical feasibility assessments);
- propose more mature technologies to reduce technical uncertainty; and
- recommend incremental or spiral development strategies.

While these initiatives may help limit the need for downstream changes, the government often adds new contract requirements to keep pace with commercial technology development or evolving warfighter needs. In this case, the government should consider applying ECPs to separate contract line items to avoid disrupting the base contract incentive structure. In addition, the government may want to prenegotiate use of the original probabilistic sharing structure for all ECPs to streamline future contract actions.

Risk-driven contracts should also help limit the government's ability to commit to too many programs by fostering knowledge-based affordability assessments. By requiring the government to set aside funding to cover the entire contract liability, the anti-deficiency laws should help reduce overextended budgets and the funding instability they induce. The government still reserves the right to deobligate funding from a risk-driven contract in response to changing priorities. However, upsetting the risk-driven sharing ratios will require more negotiation effort than, for example, borrowing money from a CPAF contract. This higher negotiation threshold may provide risk-driven contracts slightly more protection from funding cuts and the resultant schedule delays.

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In implementing the Weapon Systems Acquisition Reform Act of 2009, the USD(AT&L) directed program cost estimates to be stated at the 80 percent confidence level (Carter, 2009, p. 6). However, this directive only applies to Office of the Secretary of Defense and Service cost estimates, and not contractor proposals, which normally provide no stated confidence level for their point estimates. To enable risk-driven contracts, the government needs to start requiring probabilistic cost estimates as part of its Request for Proposal instructions. Surprisingly, this is not already common practice, and the government continues to make huge financial commitments without soliciting the confidence level of contractor cost estimates.

Weitzman (1980) states, "The government is frequently assumed to be risk-neutral as a first approximation" (p. 723). Thus, in evaluating probabilistic cost estimates, a risk-neutral program office should generally select the proposal with the lowest expected cost (all other factors being equal). However, given the current fiscal environment and the negative perception caused by overruns, a risk-averse program office may want to also consider the variance of each cost estimate. In other words, it may be prudent to select a proposal with a higher expected cost if it has a lower maximum liability than the other options.

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EndNotes

1 For practical purposes, the expected profit calculations were cut off at the 99 percent confidence levels because the 100 percent confidence levels theoretically extend to infinity.

2 The Nobel Prize is not awarded posthumously; otherwise, it is generally regarded as a given that Tversky would have shared the honor.

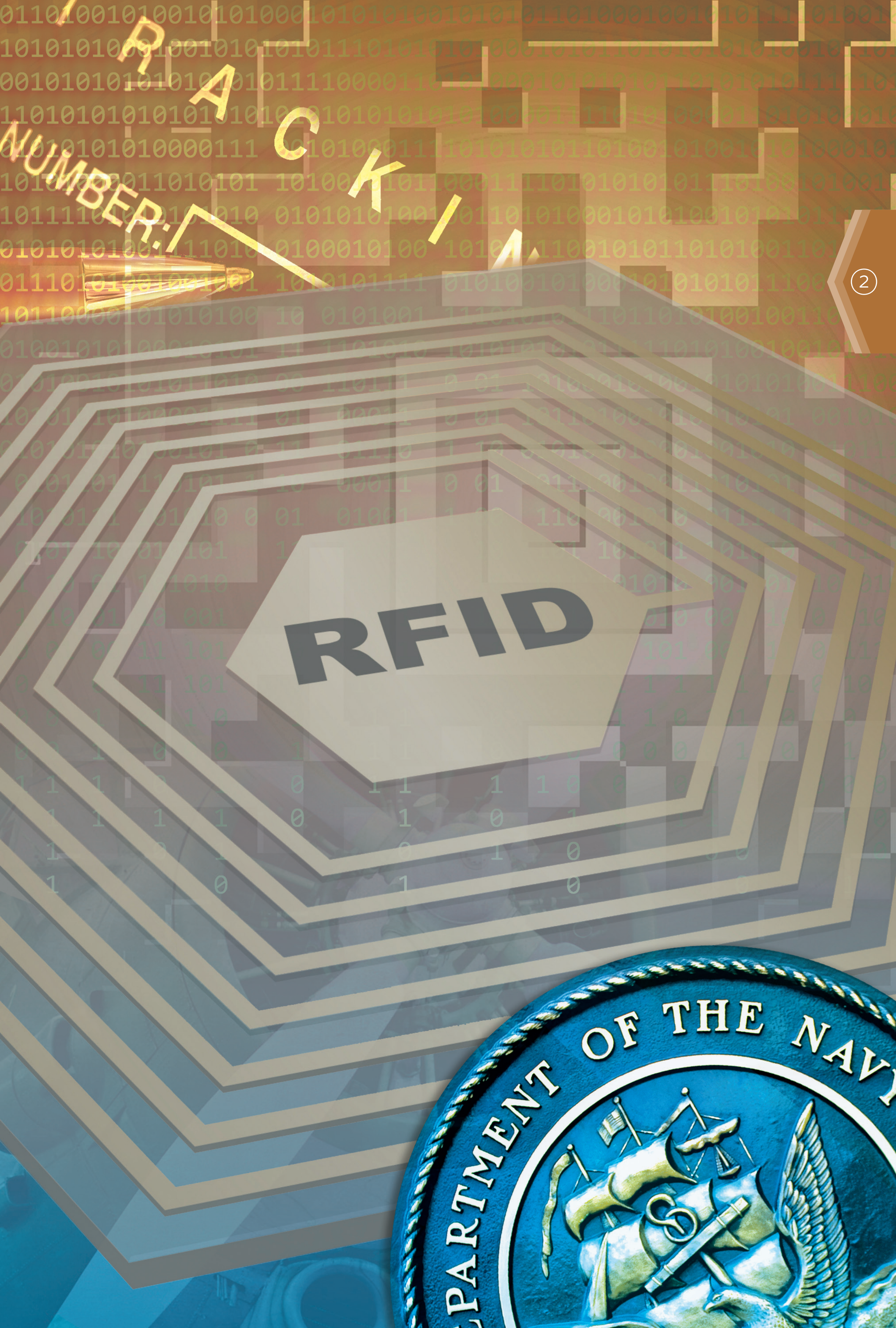
Keywords: *Aviation Maintenance, Radio-Frequency Identification (RFID), Item-Unique Identification (IUID), Scheduled Removal Component (SRC)*

Managing Life-Cycle Information of Aircraft Components

Geraldo Ferrer and Aruna U. Apte

When an aircraft component needs replacement of a serially controlled item, a maintenance officer in the U.S. Navy uses the Scheduled Removal Component (SRC) card to confirm the component's life cycle, to verify that the part is ready-for-issue, and to verify how many flight-hours it still has left. Unfortunately, replacement components are often missing the SRC cards. Further, when the cards are received simultaneously with the aircraft component requiring replacement, their encoded data are unreliable, which then precludes the part from being immediately installed. In this article, the authors analyze the impact of current paper-based life-cycle management of serially controlled parts, and investigate item-unique identification and radio-frequency identification technologies as alternative ways of tracking these parts to increase operational availability.

image designed by Janet Amedome »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RFID

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Before a plane in the Department of Defense inventory leaves the runway or carrier and is lifted in the air, it must first be put through rigorous aircraft engine maintenance. None would argue with this premise. The Aviation community, as with many other communities across the Department of Defense, is continually studying how to make the process better, faster, and cheaper, without sacrificing one scintilla of maintenance excellence and safety.

Recently, a study was published that addressed aircraft engine maintenance, demonstrating that improved operations and cost savings could be realized by rationalizing the supply network for aircraft engine maintenance in the U.S. Air Force (Ferrer, 2010). That study analyzed demand data for the Pratt & Whitney and the General Electric spare engines used in the F-16 Fighting Falcon, and concluded that pooling the inventories of Air Force bases within operationally acceptable distances would enable substantial reduction of nationwide safety stock levels. For purposes of this study, we expanded the inventory management analysis, which was originally focused on complete aircraft engines, to consider the management of individual parts throughout their life cycles and the impact of certain organizational decisions on maintenance operations.

Over the lifespan of an aircraft, specific parts are installed, removed, and replaced during a variety of maintenance procedures. When a component is removed from an aircraft, custody and ownership rights generally transfer at both intraorganizational and interorganizational levels . Because some parts are critical to flight safety, they have strictly specified life-cycle maintenance requirements that must be accurately executed, tracked, and logged. To properly service these components, technicians need information about individual parts such as the hours flown, maintenance history, and inspection data. The process of logging and tracking maintenance parts is extremely beneficial for improving readiness.

For situations in which multiple entities provide maintenance to aircraft components, at potentially different locations, the need for readily accessible maintenance history makes it necessary to keep an efficient information system. Ultimately, life-cycle management processes for military aircraft components should strive to ensure the highest levels of safety, operational availability, and squadron readiness. However, logging data using a paper-based system is labor-intensive and error-prone.

To ensure high performance of maintenance processes, many civilian and military aviation organizations are starting to implement Product Life Cycle Management (PLM), a closed-loop system that encompasses internationally standardized data-exchange technology to manage part information from cradle to grave. These tracking databases serve two important purposes. First, they serve as a part life-cycle data library, where the service technician can find the history of maintenance events. Second, engineers can examine historical part performance data to refine current preventive-maintenance practices and to minimize or prevent unexpected and catastrophic part failures.

We propose the combined use of two automated information technologies such as Radio-Frequency Identification (RFID) and two-dimensional Unique Item Identification (UID) to enhance life-cycle tracking capability for aircraft operators. The objective is that, upon accessing unique identification attributes (part number, serial number, and manufacturer's code), the maintenance technician should be able to access expended flight time, maintenance, and inspection data of critical parts. By logging a part's flight-hours, maintenance, and repair events in a centralized database, aircraft operators would reduce the cost of tracking and maintaining service history. It would also reduce the time to solve in-service problems by improving the accuracy of information exchanged between customers and suppliers. The ability to easily reference and update a part's maintenance history is expected to facilitate accurate configuration control and repair history, support accurate and efficient spare-parts pooling, and improve identification of rogue parts.

2

However, the use of RFID technology alone may not be sufficient to track a part throughout its life. RFID technology has been implemented in many military supply chain applications (DoD, 2009), but life-cycle tracking of valuable assets has been slow to incorporate advanced technologies. Similar to civilian aircraft, military aircraft have much to gain from the use of tracking technologies in support of a PLM system. To investigate how efficiencies can be attained in the logistics of aircraft engine maintenance, this research focuses on the U.S. Navy's cradle-to-grave aviation part life-cycle process.

An Approach for Component Tracking: SRC Cards and NALCOMIS

The current process uses Scheduled Removal Component (SRC) cards, which we adopted as the benchmark method. We also considered the procedures used by the Naval Aviation Logistics Command in its Naval Aviation Logistics Command Operating Maintenance Information System (NALCOMIS) to track serially controlled components (Staffieri, Holsti, & Gray, 2009). Our concerns focused on the loss of critical part history information, and the errors incorporated in the component's life-cycle information. We highlight the problems associated with the use of SRC cards and propose an approach for their gradual discontinuation. We show that an important facet of aviation maintenance would enjoy time and money savings due to decreased workloads if the correct type of tracking technology configuration is employed. Although the study centers on the Navy's F/A-18 Hornet community and its interaction with the Configuration Management Information System/Aeronautical Time Cycle Management (CMIS/ATCM) program repository, the analysis and recommendations can be applied to any aircraft that has its serially controlled components tracked by SRC cards or any other manual process.

Consider the F414-GE-400 engine, the power plant used in the F-18 Super Hornets and the E-18 Growler. The Navy plans to purchase 85 Growlers to replace the aging fleet of E-6 Prowlers. The aircraft requires two of these engines, and each engine has a modular design. The maintenance operation is initiated at the Fleet Readiness Center at Naval Air Station in Lemoore, CA, where engine modules are removed from the aircraft and replaced, unless the engine is repaired onboard a carrier's Aircraft Intermediate Maintenance Department.

Several parts installed on the F-18 Hornet require life-cycle tracking. Throughout the life of the aircraft, multiple components are removed, replaced, and repaired for reuse in the same or in another aircraft. Engineering specifications driven by safety requirements indicate that these components must be serially managed, i.e., they should be uniquely tracked, controlled, or managed in maintenance, repair, and supply by means of their serial numbers.

The NALCOMIS is the information system used to track and manage aircraft maintenance and material data throughout all Navy squadrons. NALCOMIS tracks expended flight-hours and completed maintenance actions over a part's lifetime as it exchanges hands from one command to another using an SRC card for each serially managed part. Squadron maintenance personnel primarily use this database for day-to-day management of aircraft maintenance. It can also generate many different types of maintenance reports that support tracking and planning current and future aircraft maintenance requirements. The reports also provide means to collect statistical data that can lead to the identification of high-failure parts or maintenance practices. However, NALCOMIS is not integrated with any online information network; it does not have the ability to generate an electronic card to other commands or databases, so maintenance administrators must ensure that an accurate SRC card physically accompanies each part in use or stored as spare.

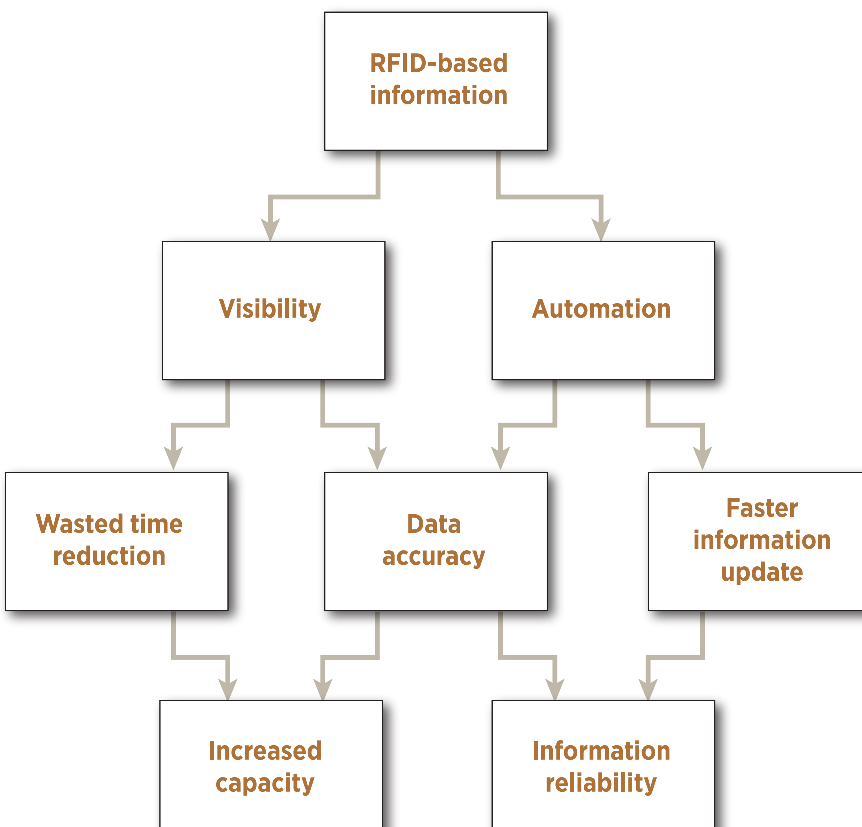
The installation of a new serially controlled part in an aircraft is the event that originates the SRC card. Maintaining physical custody of the SRC card and documenting life-cycle history updates on the SRC card are the responsibility of the squadron's Logs and Records personnel. The controlled item is removed as the result of component failure or required periodic maintenance, at which point the card is retrieved and updated.

The complete maintenance history, installation, and usage data for all items designated as SRCs are recorded on the SRC card. The cards are thorough and unambiguous. They are kept as part of the aircraft logbook or the aeronautical equipment service record as long as the component is installed. When the component is removed from the aircraft or equipment, the SRC card accompanies it through the supply chain. Updated and maintained on file by a maintenance administrator, an SRC card alone can have a direct impact on squadron readiness.

2

Occasionally, component paperwork is mishandled, particularly aboard ship. Spare parts arrive and are unpacked, and, many times, the documentation that comes with them is lost in the heat of the moment. If an SRC card is not present, or it does not have adequate information, an investigation takes place to recreate a new card with reliable history information. This effort takes time and delays the component's availability. The Appendix to this article describes the process followed when a worn part and its card are removed for repair.

FIGURE 1: PROCESS FLOWCHART FOR SERIALLY MANAGED PARTS CONTROLLED WITH SRC CARDS



One could praise the process as being conservative because it is prepared to handle exceptions such as inventory shortage (Appendix, step 4) or missing cards (step 5). However, these exceptions happen quite often, and their prominence indicates serious deficiencies in the management of serially controlled items by the U.S. Navy, leading to many instances where the squadron is faced with decreased readiness levels when many aircraft are certified as unfit to fly.

TABLE 1: COMPARISON BETWEEN RFID AND UID IMPLEMENTATION INITIATIVES

	RFID	IUID
Tagging level	Package or container	Item
Technology	UHF RF with EPC encoding	2D Data Matrix ECC200
Purpose	In-transit visibility	Life-cycle visibility
Target items	Shipment to distribution center Certain classes of supply	Serially controlled items Item value > $5000
Initial implementation	1 Jan 05	1 Jan 04

Improving this process is a priority for the aviation community, and it can be achieved with a redesign that includes the use of automated tracking technologies. Table 1 compares two initiatives in the Department of Defense: item-unique identification (IUID) and RFID. Both technologies have been considered as candidates for managing DoD-owned assets. We discuss them in the context of life-cycle maintenance management.

Tracking Technologies

RFID Technology

RFID has been widely used in military supply chain applications. It is expected to receive widespread adoption, considering its many benefits. For example, using RFID tags to automate the receiving operation can reduce labor costs, enhance accuracy, and increase inventory turnaround by decreasing the amount of time that an item spends in a distribution center. Using RFID in a job shop environment may also

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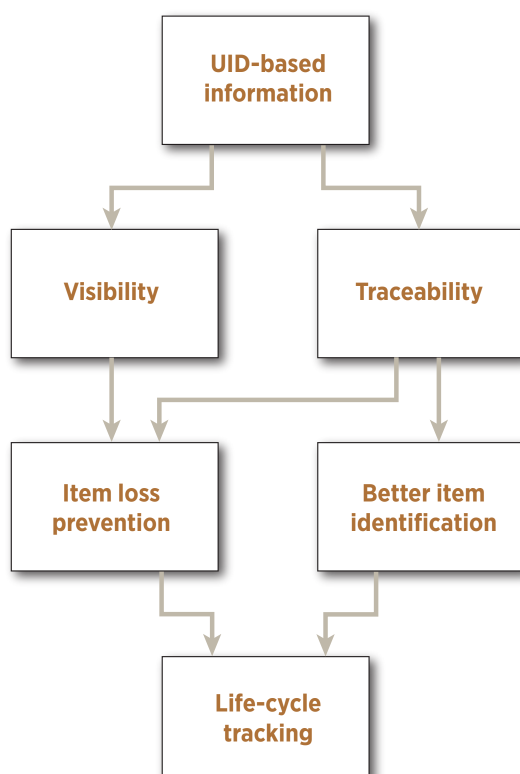
enhance tracking of high-priority items and substantially reduce cycle time for part repair/replacement (Hozak & Hill, 2010; Wang, He, & Kong, 2010; Ferrer, Heath, & Dew, 2011).

RFID technology supports the information flow in the supply chain by increasing visibility, facilitating the automation of processes, and providing greater data accuracy, as shown in Figure 1. Visibility is the ability to retrieve inventory information, as needed. Automation is the ability to update changes in inventory information as they happen, without the need for manual data entry, keeping the database up-to-date. Visibility helps reduce wasted time when a misplaced part or item needs to be located in a large inventory. Combined, automation and visibility provide data accuracy. These benefits increase process capacity and reliability (Ferrer, Dew, & Apte, 2010).

FIGURE 2: BENEFITS DERIVED FROM USING RFID IN LIFE-CYCLE TRACKING



During maintenance activities, faster information flow results in less time and effort to record component movement in the repair shop. Better visibility and faster information flow lead to faster processes, helping managers in their decision-making process and helping users of the system to access reliable information. With increased capacity, labor requirement is reduced in both the receiving and delivery points responsible for identifying, counting, locating, documenting, and managing the movements of components. Automated documentation benefits the maintenance process by helping the technician to use accurate information about the component's life cycle every time.

Moving from a familiar and trusted process to a new process using untested technology is a very uncomfortable decision for managers. There is substantial resistance to change in most organizations, even when the change brings a promise of exceptional returns. Many manufacturing facilities and distribution centers have been using barcode systems for tracking materials for years, rendering this technology mature, efficient, and familiar. Consequently, it is difficult to make the case for any other tracking technology that requires substantial investment. Likewise, an SRC card is a tried-and-tested approach for managing serially controlled components. As a result, resistance to change is one of the greatest challenges preventing the adoption of RFID or any other technology. If the cards are kept with the components at all times, and information is entered accurately, then it serves the information needs of the maintenance process. However, there are too many "ifs" that make this process unreliable, so advanced technologies must be considered, and managers must make a concerted effort to change.

Despite potential benefits, RFID technology is not fully mature, and has some limitations. The physical properties of the materials that require tracking as well as their surroundings can affect the reliability of readers. For example, liquids absorb radio frequency signals, while metals reflect them. In particular, many aviation components are made of dense materials that raise difficulties for an RF-based control system. Navy ships and depots have a multitude of equipment and surfaces that are made of steel and other materials that reflect RF signals. External factors, including noise from nearby electric motors, can impact its performance. Further, there is great concern that spurious RF signals may affect or trigger antiquated electric systems aboard military ships, with potentially disastrous consequences. Consequently, the adoption of RFID technologies to track serially controlled items requires careful planning and design.

2

IUID System

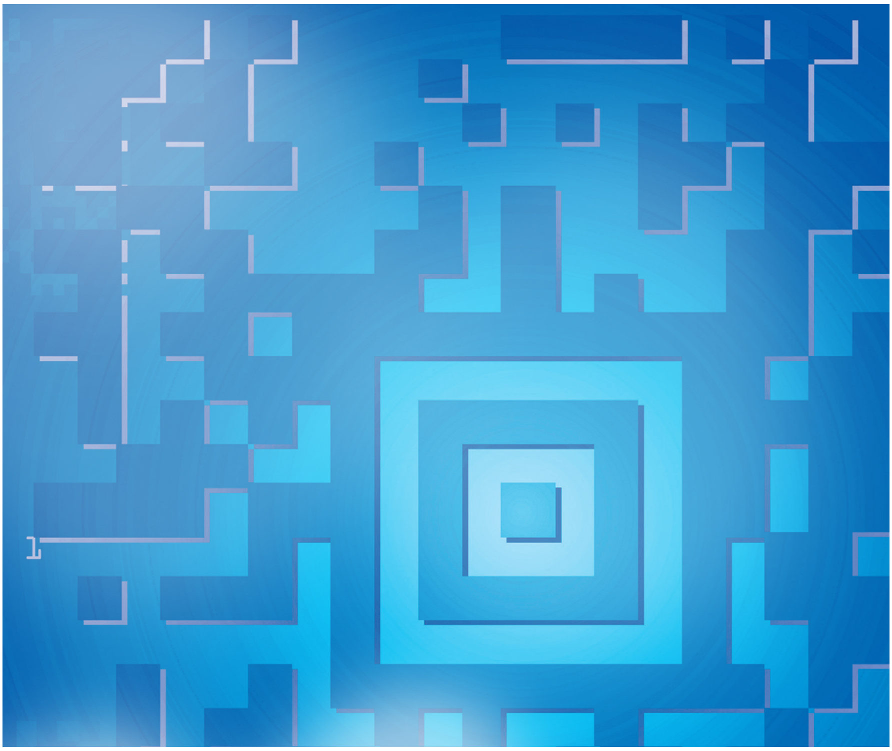
IUID is an asset identification system instituted by the U.S. Department of Defense (DoD) to uniquely identify discrete, tangible items and distinguish each of them from other identical items owned by the DoD. The identification takes the shape of a machine-readable, two-dimensional optical code using the Data Matrix ECC200 standard (DoD, 2004). UID is formatted in accordance with specified standards (MIL-STD-130). The Data Matrix ECC200 symbol has a checkerboard appearance, with each uniformly spaced, square-shaped cell corresponding to a data bit. The symbol is constructed as a combination of light and dark elements that must all be read before any characters can be recognized (Drews, 2009). The formatted data is called a Unique Item Identifier (UII). Once assigned to an item, the UII is never changed, even if the item is modified or refurbished. Like an automobile license plate, or a social security number, someone reading the UII itself will not be able to learn much about the current state of the item. A UID reader is able to recognize just the unique characters marking the item, and identify it from other similar items in the system. The main benefit is to provide a permanent identification to each individual part and use that information in many applications:

Virtually all UID data are stored offline, which provides many benefits. To retrieve information about the item with the UID mark, the user needs to access a central database, the IUID Registry, and learn permanent data elements associated with the mark. Most of this baseline data is static; it is never changed during the item's lifetime, except to record its permanent retirement (DoD 2005).

The Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics mandated the use of UID for all solicitations on or after January 1, 2004, for equipment, major modifications, and spare parts. A unique identifier is exclusively designated for each particular part, which is then registered in the IUID Registry. Each vendor that does business with the DoD has to obtain a UID number from the master database to ensure that no part in the DoD can be mistaken for another part. As the number of vendors for common aircraft parts increases, part and serial numbers may accidentally be duplicated on different components. This can result in the ordering of an incorrect part based on correct part numbers. IUID eliminates this problem. The fundamental benefit of this policy is that the UID is a permanent marking for serially managed items and the perfect life-cycle tracking enabler.

IUID Registry

The IUID Registry is the ultimate repository where all IUID data are captured. Updates are limited to change of custodianship and item retirement. The registry is neither intended nor designed to be a working database for individual programs. In fact, the registry itself does not perform any value-adding activity. Rather, its purpose is to serve as an anchor to other information systems used for life-cycle product management, such as maintenance management systems, property management systems, and other systems that may or may not yet exist. Historically,



we observed similar experience with the development of new uses for the Social Security Number in the United States, which was originally created to track retirement contributions and benefits of individuals, and is now used in a variety of private and governmental information systems to manage tax, banking, insurance, medical and employment records, education records, credit worthiness, etc. Likewise, it is expected that other benefits could be derived from uniquely identifying valuable and critical assets with IUID.

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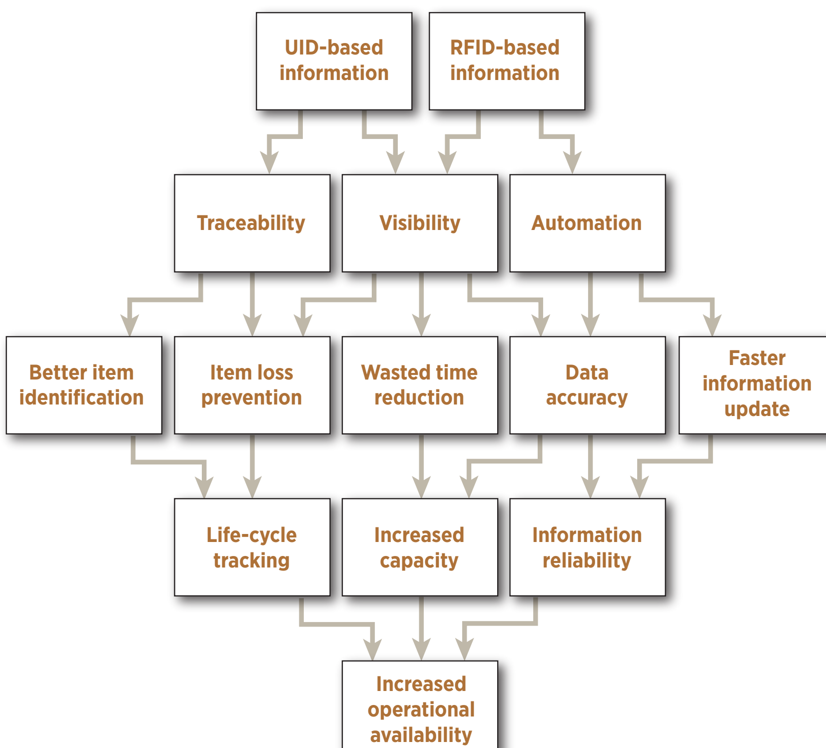
Figure 2 shows how the use of information coupled with the help of unique identifiers can enhance life-cycle tracking. Traceability is the ability to store asset information as it undergoes multiple events in its life cycle. Visibility is the ability to retrieve location information, as needed, which can be obtained with correct registration of UIDs in the IUID Registry. Combined, visibility and traceability ensure accurate item identification and the reduction of item losses—important requirements for life-cycle tracking.

FIGURE 3: BENEFITS DERIVED FROM USING UID IN LIFE-CYCLE TRACKING



Analysis

The adoption of RFID, IUID, or any other automated tracking technology for serially managed items in the naval aviation community is proceeding at a very slow pace. However, based on anecdotal conversations with officers in a variety of maintenance positions in the military services, this situation seems to be the norm, not the exception. That is, a manual control, similar to SRC cards, remains the principal mode of managing serially managed items. A survey of experienced maintenance officers found that missing SRC cards is a rather frequent event, with significant impact in the operational availability of assets (Staffieri et al., 2009). That study estimates that, by forcing early retirement of potentially good parts, each lost card results in a loss of $75k, on average.

As the flowchart in the Appendix indicates, a missing card leads the squadron to contact customer service at the CMIS/ATCM repository. The CMIS is in charge of keeping accurate data on serially managed component usage, based on a manual process using copies of the SRC cards that it receives every time a used component is removed from the aircraft, or when an RFI component is installed. If the card is missing or is inconsistent with the part, the CMIS can indicate the last time that particular part was installed. Using that information, it can then estimate the number of hours remaining in that part. In practice, that estimation is difficult to execute, and arbitrary flight-hour penalties are imposed on those components, reducing their value and accelerating their retirement.

During the 6-month period from October 2008 to March 2009, in the process of manually maintaining their database, ATCM received cards corresponding to 17,318 component replacements, an average of 140 cards per business day, an arrival rate of 17.5 cards per hour. Three clerks serve at the ATCM and, based on internal estimates, each of them is able to process six cards per hour. This leads to a capacity utilization of 97 percent.

In a deterministic process, utilization lower than 100 percent indicates that the system has capacity to perform the tasks as they arrive, without delay. However, the capacity at the ATCM is probably overestimated, and the process is not deterministic. There is no indication that the capacity measured incorporates typical distractions that happen during the workday (interruptions, restroom breaks, etc.), which would lead the effective capacity to a number lower than six cards per hour. In fact, since the card processing is admittedly a tedious activity, it is likely that service times vary substantially from card to card and are probably exponentially distributed. Moreover, job arrivals are independent, and most independent arrival processes follow a Poisson distribution.

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The combination of Poisson arrivals with exponential process times characterize a Markov process, meaning that substantial waiting lines are formed when capacity approaches 100 percent. In fact, Staffieri observed the development of large waiting lines. The backlog of cards to be processed at the ATCM program oscillated between 5,500 and 9,400 cards in a 6-month period, a backlog equivalent to 7.5–13 weeks of operation (Staffieri et al., 2009). Consequently, when an SRC card is missing, it may take a long time for the ATCM to determine if the part has any flight hours left and if it can be installed in the aircraft; it might well be that the most recent update on that individual part is among one of the thousands of cards in the backlog. Therefore, if a component is missing its SRC card, it may be several weeks before ATCM can provide an estimate of the number of flight hours remaining in the part, which of necessity will be sidelined until its status is clarified.

One solution to improving the CMIS/ATCM repository backlog would be to increase data entry capacity by adding another clerk to the system. The additional clerk will help reduce capacity utilization to just 73 percent. A simple illustration would be Markov's process wherein an hourly demand of 17.5 jobs and four servers with a capacity of 6.0 jobs would experience an average waiting line of about 4.2 cards, as shown in Table 2. However, it is possible that the effective capacity per clerk is lower than the estimated 6.0 cards/hr. As a result, the number of jobs waiting to be processed could be much larger, as shown by the examples in Table 2. If clerk capacity is too low, the system is unstable and the waiting line would increase indefinitely—a situation that we noticed at ATCM.

Adding a new clerk may contain the problem at CMIS/ATCM, but it does not address the missing SRC cards, a recurring issue that leads to grounded aircraft. Lost or inaccurate SRC cards can result in substantial part-life penalties that indirectly convert to dollars lost with the arbitrary reduction of the flight-hours remaining in the part that is missing the card. The problem stems from the lack of reliability of the card-based system. Moving to an automated PLM system would address these issues and help eliminate penalties that exist because of unreliable information management.

Figure 3 shows the potential benefits that may be derived from integrating the use of IUID with RFID to track components that exchange hands multiple times in their life cycle. These technologies provide traceability, visibility, and automation with many positive consequences, as shown in Figures 1 and 2, leading to improved life-cycle tracking, increased capacity, and information reliability.

TABLE 2: EXPECTED NUMBER OF CARDS WAITING TO BE PROCESSED, AS A FUNCTION OF CAPACITY (DEMAND = 17.5 CARDS/HR)

		3 clerks	4 clerks
clerk capacity	3.8 cards/hr	n/a	n/a
	4.4 cards/hr	n/a	194 cards
	5.0 cards/hr	n/a	8.7 cards
	5.9 cards/hr	137 cards	4.4 cards
	6.0 cards/hr	39 cards	4.2 cards

The integration between IUID and RFID technologies takes the benefits further than either of the two can achieve acting alone: it provides sustained operational availability, which translates into more aircraft ready to fly. The unique identifier in each part would ensure its correct identification against a part life-cycle database, creating the right conditions for managing a maintenance history database. Moreover, the automation provided by the RFID technology would ensure that the data are accurately recorded and up-to-date.

Conclusions

We examined the issue of grounded aircraft due to misinformation regarding the availability of critical maintenance parts: the serially managed components. The Appendix describes the part-replacement process, indicating both the material and the information flow and exposing a weakness in the process: the potential that a component retrieved from replacement-parts inventory is missing a correct SRC card and, for this reason, cannot be installed in the aircraft. Unfortunately, that seems to be a common occurrence, for which the process designates a corrective action: obtain a new card from the data repository. The SRC card holds the history of the component; without it, using the component is not authorized, and aircraft may be grounded. Since the card replacement procedure may take 7-13 weeks, missing cards are a serious operational concern.

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Many organizational issues can be addressed by implementing a combination of improvements in either a short or long time span, with costly or not-so-costly organizational reengineering. We propose two solutions: one low-cost remedial change, and a process redesign that requires substantial investment and broad commitment from all levels of leadership in the fleet, but that addresses the root of the problem.

Recommended Remedial Change with Immediate Impact

We have seen that the CMIS/ATCM Repository is understaffed, leading to almost 13 weeks of backlog, rendering customer service completely powerless to serve the maintenance officers in the aviation community. To meet the recurrent demand (without adding to the current backlog), it is necessary to increase the number of clerks maintaining the database. Considering the existing backlog, holidays, leaves, and other distractions that prevent any process from continually operating at full capacity, as well as the costly impact of not providing immediate response to maintenance officers, two clerks should be added to the standard staffing level at the database repository. Maintaining this resource level would prevent backlog build-up, a common phenomenon in services with high-capacity utilization and variable arrival and service rates.

Recommended Process Change with Permanent Impact

Increasing the staff level at the CMIS/ATCM Repository, however, is not the cure, just the palliative solution. It is important to consider the source of the problems—the SRC card itself. Figure 3 shows how the joint utilization of IUID and RFID can increase operational availability through traceability, visibility, and automation.

The U.S. Navy adopted the Optimized Organizational Maintenance Activity (OOMA), an automated system that provides maintenance officers with aircraft information on which to base daily decisions. Fortunately, both OOMA and the database software used by the CMIS/ATCM Repository have the ability to use UIIs as their primary aircraft-part identifier reference. Since the Department of Defense mandates that manufacturers mark serially managed items using UID technology, the U.S. Navy should accelerate the adoption of UID as the main aircraft-part identifier. These tags should be coupled with passive RFID to ensure timely and accurate recordkeeping, eliminating the number of instances in which a part that is believed to be RFI is of unknown quality because of the lack of reliable records.

Our discussion focused on the life-cycle management of aircraft components. The same concerns exist in the life-cycle management of other valuable assets, including ocean-going vessels, armored vehicles, off-road, mining, and other heavy-duty machinery. Managers should plan for life-cycle tracking of high-value moving assets using automated technologies. A combination of passive RFID and a 2-D barcode such as Data Matrix ECC200 seems to be the right solution for the problem.

Acknowledgments

The authors are grateful to LT Will Gray, USN, Aircraft Intermediate Maintenance Department, *USS Ronald Reagan*, for clarifying and validating the SRC card process; and to LCDR T. J. Staffieri, USN, School of Aviation Safety, Naval Air Station Pensacola, for the many discussions about the SRC card maintenance database at the CMIS/ATCM. This work was supported in part by the Acquisition Research Program of the Naval Postgraduate School under Project No. F09-035.

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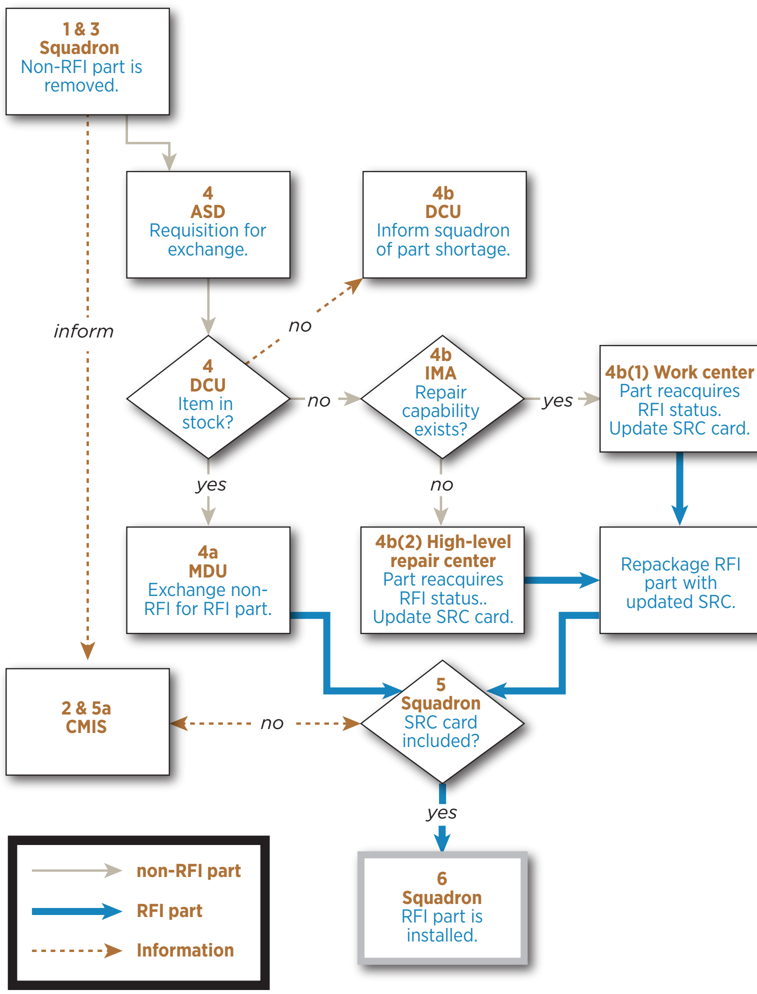
Appendix

Process for Recreating a Scheduled Removal Component Card



1. The non-ready-for-issue part (non-RFI) is removed and its SRC card is updated with the new status.

2. A copy of the SRC card is sent to the Configuration Management Information System (CMIS), which keeps information on all serially controlled parts.

3. The updated SRC card is packaged with the corresponding non-RFI component to be exchanged for a ready-for-issue (RFI) component.

4. A requisition document for a replacement part is conveyed to the Aviation Support Division (ASD). The Document Control Unit (DCU) personnel process the request and determine if an RFI item is in stock.

    a. If the RFI item is in stock, then the process moves to Material Delivery Unit (MDU). The MDU sends the RFI item to the squadron. The non-RFI part and its card are collected in exchange for the replacement RFI part.

    b. If the RFI item is not available, then the squadron is informed. The SRC card of this non-RFI part is verified and updated. The non-RFI item is sent with its card to the Intermediate Maintenance Activity (IMA) facility for repair.

        (1) If the IMA has repair capability and the part is not beyond the capability of maintenance, then a work center and work priority is assigned to the part by Production Control. The part is then transported to a work center, where it is repaired and receives RFI status.

        (2) If the IMA work center does not have repair capability, then the part is sent to the next-higher-level repair facility, where it is repaired and receives RFI status.

5. The squadron receives the part, opens the package, and verifies if the SRC card is included.

    a. If the SRC card for the part in inventory is missing, then the part is not used because the maintenance officer cannot establish the number of flight-hours that are still available in it or even if the part is RFI. The CMIS is contacted to re-create an SRC card with an estimated number of flight-hours that the part can still safely deliver. The squadron waits for confirmation

6. Once the SRC card is confirmed to be with the part, the card is updated and the part is installed in the aircraft.

Keywords: *Program Termination, Weapons Acquisition, Army Aviation, Stealth, RAH-66 Comanche*

RAH-66 Comanche–The Self-Inflicted Termination: *Exploring the Dynamics of Change in Weapons Procurement*

Julien Demotes-Mainard

An intriguing question in weapons acquisition is why some weapons programs—initially designated Major Defense Acquisition Programs (MDAP)—collapse after a long development process, resulting in wasted money and expertise. A salient illustration is the RAH-66 Comanche stealth helicopter. For 20 years, the Army designated the RAH-66 an MDAP. Yet, in 2004 the Army decided that the RAH-66 was no longer affordable. What changes led the Service to reverse its position? This study shows that despite the explicit Army posture favoring the program, the Comanche had in fact suffered from an implicit and progressive decrease in support within the Service.

image designed by Diane Fleischer »


RIP
RAH-66

The RAH-66 Comanche Scout/Attack (SCAT) helicopter represents an unusual case study for those addressing the question of program termination in public policy. Certainly, the Comanche story does not fit the classical model of how to terminate a major weapons program after it enters the Department of Defense (DoD) procurement process. Interestingly, the aircraft was not cancelled by the DoD in its oversight role of the Services as was, for example, the Future Combat System program (Montgomery, 2009). Nor did Congress, despite its usual concerns about growing costs and schedule slippages, eventually direct DoD to discontinue the funding. According to many of those who witnessed the demise of the next-generation helicopter, the program, after a decade of languishing in program instability, was—*finally*—healthy and on track by the time it was terminated in 2004 (C. M. Bolton, personal communication, November 23, 2010).

Surprisingly enough for observers of defense policy, the decision to kill the Comanche was made by the Army itself—the very same institution that was expected to enjoy Comanche capabilities in the future. Moreover, the decision came at a time when the Comanche program was eventually showing progress (U.S. Senate Committee, 2005, pp. 134–136).

At first glance, the case study presented here appears out of the scope of any traditional hypothesis on program termination in public policy. Comanche cancellation fails to illustrate the "lengthy political struggle" expected to surround the termination decision—a phenomenon first observed by Eugene Bardach in his article "Policy Termination as a Political Process" (1976, p. 125). A former Deputy for Aviation to the Secretary of the Army, who had been following the program for over 20 years, highlights this absence of clear antagonism over the program: "Nobody stood up and opposed the Comanche. The enemy was the price, which ran up" (Army source, personal communication, November 15, 2010). During Donald Rumsfeld's second tenure as Secretary of Defense (2001–2006), there was clear evidence showing the Office of the Secretary of Defense (OSD) was dissatisfied with the program, but unlike the Crusader artillery, DoD didn't dictate cancellation of the Comanche (M. W. Wynne, personal communication, June 6, 2011). It seems that Comanche termination was a pretty peaceful process, a circumstance that also challenges Robert D. Behn's assertion that termination invariably triggers strong resistance from those who benefit from this particular policy or program (Behn, 1976, p. 393). In the case of Comanche, numerous interviews showed that very few in the Army (even among the pilots) were reluctant to terminate the program, and no organizational response took place to defend the vanishing aircraft—a situation clearly articulated by the former Assistant Secretary of the Army for Acquisition, Logistics and Technology, who played an essential role in the termination :

> As a result, it was one of the least painful terminations that we ever had, because everybody wanted it. The Army can't use it; it doesn't fit any need, so the warfighters don't want it. Warfighters want upgrades to the current aircraft, self-protection, new fixed-wing, new [Unmanned Aerial Vehicles]. So, if you can take the money and buy the stuff for them, they're happy. Contractors were happy; when not building [Comanche], they're building other stuff, so the workforce stays employed and they remain comfortable. Congress is happy as long as the voters, who were the employees of the contractors' facilities, are still employed. (C. M. Bolton, personal communication, November 23, 2010)

Comanche's case also challenges conventional hypotheses about weapons' procurement. The civil-military's model of military innovation that depicts the Services as conservative entities, unable to evolve without civilian intervention (Posen, 1984), fails to explain how the Army, which invested $6.9 billion in the program over 20 years, eventually changed course on its own initiative toward termination. The classical "technological imperative" argument makes things even more troubling: With sensor integration, high agility, and low-observable technology, Comanche had promising capabilities beyond anything that still exists today in the Army Aviation inventory. Yet the Army finally refused to go further with the aircraft and, instead, decided to reallocate the money to rapidly modernize existing platforms (AH-64 Apache, UH-60 Blackhawk, and CH-47 Chinook), and to ultimately fund a far less hi-tech scout helicopter, the ARH-70 Arapaho (also cancelled in 2008).

Is there a logical, easy-to-defend explanation for Comanche's cancellation? To this author, the case appears as a clear illustration of Peter deLeon's "financial imperatives" termination (deLeon, 1983, p. 634). Despite encouraging capabilities, Comanche was simply not worth the 40 percent of the Aviation budget it was projected to swallow until program completion (Bonsignore, 2004, p. 104). A former Comanche program manager commented:

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> The Global War on Terror was chewing-up our Blackhawks, Chinooks, and Apaches in such a frenetic way, that the Army had to get more resources to upgrade these aircraft, and the only way was to kill one of the programs; and so the Comanche got killed. (R. P. Birmingham, personal communication, November 19, 2010)

Like the former program manager quoted here, every actor interviewed agreed that Comanche termination was, above all, a financial decision made by the Army to restore the balance in the Aviation budget, and enable the much-needed upgrades to aircraft that were deployed to Iraq and Afghanistan. But despite its relevance regarding the final decision, the "financial imperative" model tells little about the 20-year process that eventually led the Army toward cancellation.

Just before the end of the Cold War, Comanche (formally known as the LHX [Light Helicopter Experimental] program) was still the focus of Army modernization: "It was the centerpiece of Army R&D [Research and Development] across the board. It was a very expensive program," stated a former Deputy for Aviation to the Assistant Secretary of the Army for Acquisition, Logistics and Technology (M. R. Kambrod, personal communication, November 19, 2010). One of the first program managers on Comanche also recalls that it was "the number one priority" at the time for the Army (Army source, personal communication, February 28, 2011). However, 15 years later, Comanche moved from the status of a critical development program down to a termination that nobody ever seriously opposed in the Army.

This article demonstrates that Comanche termination can be understood within the framework of a dynamic correlation between the external disruptions the program underwent during its development, and the level of the Army's commitment to proceed with the program. Indeed, previous studies indicated that weapons systems are likely to survive external changes (i.e., the end of the Cold War or the beginning of the Global War on Terror, or GWOT) that threaten their core rationale, if the interested Service continues to manifest an undeterred resolve toward the completion of the program (Kotz, 1988; Hampson, 1989, pp. 153–179). There is still a tendency in modern political science and defense analysis to postulate that weapons programs logically enjoyed a die-hard constituency inside their own Service. Few studies enlighten that military services can sometimes show disinterest in a system (Werrell, 1989). Even fewer contemplate the Services' support as a dynamic variable that can be affected by major strategic and budgetary shifts.

The case of Comanche illustrates the consequences of declining support to a weapon program's termination within a military service. After the Vietnam War and the refocus on the European theater during the 1980s, the Army was strongly supportive of the need for a new scout helicopter; and a wide consensus was prevailing between the Service and DoD on the tactical imperative to develop a stealth rotorcraft. The breakup of the Soviet Union in 1991, however, abruptly ended this agreement. DoD went on to raise serious concerns during the 1990s over cost, schedule, and performance of the program. At the same time, Comanche was decreasingly perceived as a "top priority" by the Army, which in a constrained budget environment, favored the modernization of its ground force components. To circumvent this spiral of neglect, Comanche's advocates worked on securing constituencies inside the Army by extending the range of capabilities of the aircraft. Beginning its development as a light Apache companion—a strategy that made sense only to Army Aviation—Comanche was, by the time of its termination, "an information collection and distribution node in the network" (C. H. Allen, personal communication, February 27, 2011) that would have provided information to every Army unit on the battlefield. As a result, the program evolved from concept and development throughout the early 2000s as a highly capable (also expensive) rotorcraft, which was only superficially relevant to the operational requirements of the GWOT. Additionally, the Afghanistan and Iraq campaigns marked a critical shift in the Army's mindset. Comanche was a cornerstone of Chief of Staff of the Army General Eric Shinseki's and U.S. Army Training and Doctrine Command (TRADOC)'s modernization plan; but prospects abruptly became gloomy for the program when Army General Peter Schoomaker, a former Special Forces' operative, stepped in to replace Shinseki. The special operations community was one of the least interested in Comanche, and their operational perspectives had been gaining favor within DoD since the early successes of operation Enduring Freedom.

The Maturity of Army Aviation and the Formation of a Military-Political Consensus on a Stealth Helicopter

The Aviation Mutation Toward the Attack Mission

The LHX (precursor to the Comanche) earliest concept explorations are deeply connected to the Vietnam practical experience that for the first time permitted the clarification of the strengths and weaknesses of rotorcraft in large-scale operations. The 1958 *Airmobility* doctrine that called for rapid troops and hardware lift, combined with armed assistance to ground forces (Department of the Army, 1958, pp. 6–7), had indeed proved to be controversial during the war (Allen, 1993, p. 16).

On the one hand, Army Aviation rotorcraft demonstrated their combat effectiveness as close air support (CAS) and escort platforms that can operate in mid-intensity conflict (Williams, 2005, p. 171). Three helicopters were in the midst of this recognition: the AH-1 Cobra, the OH-6 Cayuse, and the OH-58 Kiowa. They operated closely together: The AH-1 acted as a firepower delivery vehicle, while OH-6 and OH-58 were deployed forward to find targets for the Cobra and other platforms (Rottman, 2007, p. 58). But, on the other hand, Vietnam-era rotorcraft demonstrated their inherent limitations on the modern battlefield. They were vulnerable—U.S. Armed Forces lost a total of 4,879 helicopters from 1962 to 1973 (Stoffey, 2008, pp. 323–324)—and also too lightly armed: Cobra's early versions suffered from limited killing power until the

Army equipped the aircraft with the heavier 20mm M61A1 Gatling gun in 1969 (Bishop, 2006, p. 23). OH-58 and OH-6 faced a similar problem: "Those were not armed, and in Vietnam they ran around trying to draw fire to find where the targets were. That was the aerial scout, as it really started" (Army source, personal communication, November 15, 2010). The Vietnam campaign undoubtedly shined a spotlight on scout and attack rotorcraft, but their legitimacy in the overall Army was yet to be confirmed. While the Army was shifting its focus back on the European theater to counter the growing conventional Soviet threat, helicopters were still regarded by most as vulnerable pieces of hardware (Allen, 1993, p. 16). Studies of the Yom Kippur War showed the Army that aircraft, and especially helicopters, may soon evolve on a battlefield saturated with surface to air missile (SAM) sites, anti-aircraft (AA) guns, and man-portable air-defense systems (Williams, 2005, p. 173). In 1976, Army General William DuPuy's *Active Defense* doctrine became the first TRADOC doctrine, and widely acknowledged that NATO forces will fight outnumbered in a very fire-intensive environment. DuPuy's doctrine emphasized the use of massive firepower and protection, a strategy that implicitly recognized the predominance of artillery and armor divisions to counter the Soviet steamroller (Department of the Army, 1976, pp. 3/5–3/6).

Active Defense represented both a tremendous opportunity and a serious challenge for helicopter proponents. Indeed, Aviation would be likely to receive additional funds if rotorcraft could perform the anti-tank mission DuPuy's doctrine so adamantly stressed. AH-1 Cobras, armed with Tube-launched, Optically-tracked, Wire-guided missiles, were deadly weapons against armored vehicles; however, Cobra's skinny airframe was unable to accommodate additional firepower, such as a 30mm cannon (Bardin, 1994, pp. 135–136). The heavy attack requirement asked for the development of a more capable aircraft, which would demonstrate to the Army and other Services the effectiveness of rotorcraft in fire-intensive operations. Even though the Air Force, which regarded the dispersion of tactical air power as a threat to its own CAS capabilities, insisted that the A-10 would suffice for the mission (Army source, personal communication, November 15, 2010), the Aviation directorate was able earlier in 1973, with the blessing of then-Chief of Staff of the Army Creighton Abrams, to secure the Advanced Attack Helicopter (which later became the AH-64 Apache) in the top-priority Army programs package, dubbed the "Big Five"—Abrams, Bradley, Patriot, Apache, and Blackhawk (Allen, 1993, p. 23).

The "Flying Humvee"

In 1982, Aviation was finally granted branch status; the same year, the *AirLand Battle* doctrine was published. The opposite of the fairly static *Active Defense* strategy, *AirLand Battle* shifted the focus to deep-strike attacks that aimed to cut the first Soviet echelon from its reserve and logistics supplies (Department of the Army, 1982, p. 2/2). Maneuver became the centerpiece of the U.S./NATO strategy to confront the Soviet army in Europe; and, with their speed and versatility, attack helicopters were logically tasked by the Army to play a decisive role on the battlefield (De Durand, 2003, p. 22). The AH-64 Apache and its Hellfire missiles were now in the planning to join the arsenal and perform the heavy attack role attributed to Aviation; but, as the strike mission grew in importance, it appeared to Army Aviation military leaders, in the early 1980s, that the combined portfolio of OH-6 Cayuse and OH-58 Kiowa was not sufficient enough in numbers to properly carry out the forward scout mission crucial for Apache targets' designations:

> There was a void of 600 aircraft in the Army Aviation inventory for something similar to the Bell OH-58. So the program started off with having people from Fort Rucker coming and asking for a replacement for this aircraft. Then it turned into an

> attack aircraft, and then it became a scout-attack aircraft, and that ended-up as the basis for the LHX program. The intended replacement for 600 Kiowas went away; instead, the Army decided that a much more capable scout-attack was needed, and that became the LHX. (M. R. Kambrod, personal communication, November 19, 2010)

In January 1983, the LHX program was initiated to address this void in inventory for a more survivable and faster scout aircraft that would also be capable of engaging targets, if necessary. In its earliest concept phase, the LHX was supposed to fit into the "lower portion" of the high-low mix, produced in combination with the "high end," heavier Apache. The requirement for a mixed scout/attack aircraft that fully took advantage of the lessons learned in Vietnam (better survivability, targets' engagement capability) was strongly supported by Army Aviation, and especially its commanding officer, General Carl McNair. Fort Rucker then started discussions with the civilian leadership of the Army, and the idea of a new helicopter soon met the enthusiasm of proactive then-Under Secretary of the Army James Ambrose (M. R. Kambrod, personal communication, November 19, 2010). Army Aviation was adamant on the need to replace its current scout rotorcraft, but Ambrose took a broader approach and saw in this project the promise for developing a low-cost, multipurpose airframe that would eventually replace not just the OH-58 and OH-6, but all utility, light attack, and scout aircraft in the inventory:

> The Comanche started as the LHX program, and it was the brain child of Jim Ambrose. LHX was like Humvee. Humvee is a very good engine and chassis you can reconfigure; it can be an ambulance, it can be a truck, it can carry a machine gun, it can do a lot of things. Ambrose wanted a helicopter just like that—a good airframe and a good engine—and it can be a scout helicopter, attack, and utility. (P. L. Francis, personal communication, November 18, 2010)

LHX started as a consensus between Army Aviation and TRADOC, which were looking for the next-generation scout helicopter, and the civilian leadership of the Army, led by James Ambrose, which agreed on the development of a versatile airframe. On the operational side, LHX was strongly supported by the Army because attack and scout helicopters were increasingly seen by Army leaders as a focal capability to perform the deep-strike mission envisioned in *AirLand Battle*.

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Aviation's operational perspectives were gaining thrust inside the Army. Institutionally speaking, the branch status obtained in 1982 allowed Army Aviation to handle its acquisition process, and better defend its programs against tank, infantry, and artillery requirements (Allen, 1993, pp. 47–48). Finally, the personal involvement of the influential Jim Ambrose helped the LHX to swiftly reach the status of top priority within the Service (T. P. Christie, personal communication, June 30, 2011). The LHX would be a low-weight, low-maintenance, single pilot aircraft that would enter Aviation inventory in very large numbers (5,023 units:

3,072 scout-attack, and 1,951 utility), with a modest fly-away unit cost of roughly $3 to $4 million for the utility version, and $5 to $6 million for the SCAT design (U.S. House Committee, 1984, p. 250).

The near-obsolescence of the Vietnam-era OH-58, OH-6, UH-1, and AH-1, combined with the planned cost savings that would have materialized in production and sustainability from buying a multipurpose airframe, were sufficient arguments to persuade civilian leaders that a new program should be developed to face the Soviet air defense system on the European front (U.S. Senate Committee, 1984, pp. 1308–1314). In 1983, it was assumed that the Soviet air defense branch (V-PVO), along with the Warsaw Pact air defense troops, could have deployed in wartime over 6,400 AA guns, 6,300 SAM launchers, and 4,000 interceptors to thwart any NATO attempts to control the air and deny the conduct of forward operations (International Institute for Strategic Studies, 1982, pp. 132–133). The Western perception of a Soviet qualitative increase in military hardware was the core incentive that drove, during the 1980s, the requirements for new programs; and the more the balance of power was perceived as shifting in favor of the Soviets, the more U.S. weapons were accumulating capabilities to match this alleged Soviet progress.

LHX was no exception to this dominant mindset; the program was perhaps even more sensitive than others to threat perceptions, as LHX had not been started according to a strict requirements' approach, but was instead designed as a fairly open program, able to absorb, during its Demonstration/Validation (Dem/Val) phase, a large quantity of the new promising technologies that were emerging during the 1980s (digital optical control system, ballistic tolerant components, embedded diagnostics, etc.). Stealth was one of them, but the Army wasn't familiar with it until the early 1980s, when the DoD acquisition overseer, then-Under Secretary of Defense for Research and Engineering (USD[R&E]) Richard de Lauer, and his military assistant, John Douglass, started to actively encourage the Services, with the blessing of Deputy Secretary of Defense Paul Thayer, to implement stealth on their ongoing tactical programs (T. P. Christie, personal communication, June 30, 2011). The Pentagon was increasingly envisioning stealth as a crucial capability to defeat the proliferation of Soviet SAM and radar sites. The Director of Program Analysis and Evaluation at the time recalled:

> In attack aircraft that would need to penetrate hostile airspace, there was an emerging consensus on the need to reduce the signature of the airplanes in every dimension, and stealth was a particularly salient element of that debate in the 1980s. (D. S. C. Chu, personal communication, June 27, 2011)

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In the face of DoD enthusiasm, the Air Force strengthened its stealth requirements on the F-22A Advanced Tactical Fighter (ATF); the Navy agreed to develop the technology on the A-12 Advanced Tactical Aircraft (ATA); and, to a lesser degree, the Army adapted it on the RAH-66 LHX. The low-observability requirement on LHX was, at the time, consistent with its operational assignment. The aircraft was supposed to proceed ahead of the offensive force to search for targets in a very high-threat environment, where Soviet air-defense systems would have seriously endangered the survivability of more “conventional” scout helicopters.

The First External Shock—The Demise of the Soviet Threat and the Comanche’s Quest for Staying Relevant within the Army

Losing its Rationale

In the mid-1980s, the Soviet threat was undoubtedly dominant in the strategic landscape, but with Gorbachev’s Perestroika in 1986 and the diplomatic re-warming of U.S./Soviet relations, the DoD budget was starting to stagnate. During the first half of the decade, defense spending literally skyrocketed from $130 billion in 1980 to $281 billion in 1986, but between 1986 and 1990, the budget rose only modestly from $281 to $286 billion (in 2005 dollars) (Congressional Research Service [CRS], 2005, pp. 27–28). As the political imperative for an ever-increasing military budget was fading away, the technological (and cost) inflation of LHX started to draw the attention of Congress and of the OSD (General Accounting Office, 1987, pp. 7–8). Still in its concept formulation phase, the program was not yet benefiting from a strong constituency in Congress, which subsequently did not hesitate to slash the program’s funding, thereby raising concerns over the Army’s choice to fund the LHX development at the expense of Apache and Blackhawk production (Galindo, 2000, p. 54). In DoD, the program underwent a Defense Acquisition Board review that forced the Army to restructure the program. Following the recommendation of a RAND study, the new USD(R&E) was doubtful that the technology for a single pilot helicopter was available, and he subsequently took action to cancel the one-seat design (D. A. Hicks, personal communication, June 29, 2011). The OSD Director of Program Integration managed to convince the Vice Chairman of the Joint Chiefs of Staff and the Deputy Under Secretary of Defense for Acquisition to put a price and a weight cap on LHX (T. P. Christie, personal communication, June 30, 2011). The price for Army Aviation to enter the Dem/Val phase (Milestone I) was to go along with the more conventional two-seat design and drop the utility variant, which subsequently reduced the procurement quantity to 2,096 units. The fall of the Berlin Wall ushered in another restructuring in 1990, which further decreased the procurement quantity to 1,292. In April 1991, the Boeing/Sikorsky contractor team was selected to develop the truncated LHX SCAT program, subsequently renamed the RAH-66 Comanche (Werthman, 2007, p. 2). In an additional irony, later in December of that year the Soviet Union, along with the Warsaw Pact threat, collapsed.

The former Comanche program manager (1984-1991) recalled that the demise of the Soviet Union inflicted a severe setback to the Comanche's relevance (Army source, personal communication, February 28, 2011). Since its inception, the program had been tailored and sold by Army Aviation as a means to confront the Soviet war machine in Europe. The Army leadership was still strongly committed to swiftly fielding high-tech weapons systems such as the RAH-66, but on the other hand, the administration was increasingly concerned with rationalizing the Pentagon budget handed out by the Reagan build-up. The disappearance of the Soviet threat acted as an external shock that eventually broke the consensus between the Army and DoD on the imperative nature of Comanche's further development. However, under the George H. Bush administration and Bill Clinton's first mandate, DoD was not disposed to terminate the program. Two major rationales were dictating this choice. First, even if the absence of a peer-competitor undoubtedly relaxed the incentive to rush weapons programs into production, the United States was willing to maintain a strong leadership position in international affairs, which called for a downsized, but still dominant, armed forces (Kagan, 2007, p. 146). Second, the RAH-66 was at the time the only advanced-technology program available to sustain the know-how of the industrial base in helicopter design (Galindo, 2000, p. 65). These two motives drove DoD's decision to enforce two additional restructurings (approved in 1993 and 1995) that further streamlined the Dem/Val phase, limited the funding for research and development, and deferred production indefinitely (Office of the Inspector General, 2003, p. 16). The Comanche was kept barely alive in case its capabilities and technology would be remotely required.

The Apache Rivalry

Another obstacle for the Comanche was its complex relationship with the AH-64 Apache. The AH-64 was Comanche's *raison d'être*. The RAH-66 was originally designed as a light companion that would have evolved in pair with the Apache, in a sensor/shooter configuration. But during the 1980s, the Comanche mutated, in accordance with the perception that the Soviet threat was strengthening into a heavier, stealth, two-seat helicopter (T. E. White, personal communication, June 23, 2011), with strong air-to-air and air-to-ground combat capabilities that could carry a significant payload (4 Hellfire and 2 Stinger missiles in internal weapons bays, and a 20mm canon on front). In a declining defense budget environment, critics were prompt to note that Comanche capabilities, which matched or even surpassed those of the Apache, were blurring the role of the two helicopters (CRS, 1996, p. 2). Additionally, and according to many interviewees who witnessed the evolution of the RAH-66 program during the 1990s, the development of the Longbow target acquisition system raised, within DoD, the question of whether the Apache could assume its attack mission efficiently without the RAH-66. Comanche became frequently portrayed as a too-early follow-on of the AH-64, presenting no undisputable needs for its SCAT mission (G. F. Decker, personal communication, November 3, 2011). The perceived lack of firm necessity and added value complicated the task of the Comanche program office to properly "advertise" the program. In a restricted budget environment, the two programs were indeed forced to compete, and Comanche's survival was in balance with Apache upgrades (DoD, 1993, pp. 40–41).

Rebuilding a Constituency

The Comanche program office was deeply concerned by its languishment in the Dem/Val phase. The stealth rotorcraft was indeed facing two crucial challenges that could potentially lead toward its termination: (a) The RAH-66 technology was not yet proven, and (b) to date, the aircraft had been unable to secure an indisputable role within the Army. To address the first challenge, the program office persuaded the Aviation Program Executive Officer and the Army Acquisition Executive to build, as part of the restructuring, two flying prototypes. The objective was to demonstrate to civilian leaders the capability of the aircraft and, implicitly, to convince DoD and Congress to remove the production deferment (Galindo, 2000, pp. 69–70). The first prototype flew in 1996, and the political move undertaken by the program office was a stark success among Congress. The fly-off achievement had been a great help for the contractors to remind Congress that jobs were and would be guaranteed in their districts if the program proceeded. House and Senate Armed Services Committees were now willing to pour additional funding into the program (CRS, 1996, p. 2). The Comanche program received $282 million for FY1998 and $391 million for FY1999 (CRS, 2000, p. 6). Despite the persistent opposition of Congressman Peter DeFazio (D-OR), the two program managers, who together covered the 1997-2003 period, confirmed during interviews that the Comanche, which employed more than 10.000 people in 42 states, enjoyed robust support from Capitol Hill (R. P. Birmingham, personal communication, November 19, 2010; J. L. Bergantz, personal communication, June 7, 2011). The Pentagon position remained, however, unchanged. OSD did not object to the program and let the Comanche proceed with a new restructuring in 1999; but in the eyes of many civilian leaders, Comanche still was a low priority for Army modernization (J. S. Gansler, personal communication, November 16, 2010).

Securing a New Role Inside the Army—The "Quarterback of the Digital Battlefield"

The Army went through a significant reorganization during the 1990s. Despite the crushing blow inflicted on Saddam Hussein's forces in the Gulf, its whole doctrine and force structure were based on a potential conflict with the Warsaw Pact in Europe. Its divisions were large, heavily armored and armed, and little incentive had been put, so far, on rapid strategic deployment and tactical agility—two capabilities that were increasingly seen by political leaders as imperative to match the proliferation of limited conflicts throughout the world (the Gulf, Somalia, and Bosnia) (Jackson, 2009, pp. 45–46). With Les Aspin's *Bottom-Up Review*, the Army drastically downsized its active force, going from its 18 divisions' peak of the 1980s down to 10 divisions at the end of the 1990s (DoD, 1993, p. 28). To put it simply, the Army was tasked to do more (be more deployable, more agile, more reactive) with less (less volume and less budget). The Army Chief of Staff's answer to meet this challenge—*Force XXI*—was an initiative to bolster the Army's effectiveness on the battlefield: Smaller forces would do greater damage by sharing real-time situational awareness. *Force XXI*'s objective was to take full advantage of the "information revolution" that was occurring during the 1990s. In the second half of the decade, General Dennis Reimer, Chief of Staff of the Army (1995–1999), in his *Army After Next*, confirmed the cornerstone concept of force "digitization" (Adams, 2008, pp. 38–40). His successor, Shinseki, was pressed by the Task Force Hawk episode to urgently solve the Army's deployability issue. His answer was a two-step program (Interim Force, then Objective Force) to eventually field a whole new generation of lighter, easier-to-deploy vehicles, with improved ISR (Intelligence, Surveillance, and Reconnaissance) and precision strike capabilities (the FCS program) (Jackson, 2009, pp. 45-46).

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As the Army was reshaping according to the "network-centric warfare" concept, in 1997 the Comanche program office and TRADOC were in agreement that the RAH-66 would have to fully embrace this new direction to secure an indisputable role in tomorrow's Army, and finally escape the agony of its everlasting Dem/Val phase (Williams, 2005, p. 346). The Comanche program office's and TRADOC's idea was to expand the capabilities of the aircraft toward a much more integrated system that would provide real-time situational awareness to every Army unit on the battlefield by taking full advantage of the fast-evolving information technology. The program's mutation into a holistic ISR platform (later dubbed the "Quarterback of the Digital Battlefield") rather than a simple SCAT aircraft, which made sense only to Army Aviation, would require significant upgrade (Longbow radar, enhanced software). The effort was endorsed by then-TRADOC Commander John N. Abrams and Shinseki, who envisioned the system as a critical capability to win the information war (R. P. Birmingham, personal communication, November 19, 2010). But, in retrospect, the Comanche program office/TRADOC initiative to bolster Comanche visibility had conflicting effects. On the one hand, it allowed the RAH-66 to enter the Engineering and Manufacturing Development (EMD) phase by securing the much-needed support of the Army's top leadership (Shinseki). On the other hand, for those who were not closely associated with the program, Comanche's enhanced role was becoming harder to conceptualize within the modernization effort the Army was trying to promote through the FCS program. The Program Analysis and Evaluation Director of Land Forces Division at the time highlights the issue:

> The Army vision was a future force that has very good sensors, so the idea was to substitute knowledge for armor and to be able to strike precisely at long-range. It wasn't clear that Comanche's sensors would fit in that, and if you have long-range precision munitions, why send a helicopter out there? (M. F. Cancian, personal communication, June 9, 2011)

A former program manager also confirmed that despite its "transformation," Comanche failed to build the anticipated consensus over its role and mission:

> The Army didn't understand the Comanche requirement. For Division Commanders, Corps Commanders, and many of the four-star generals who weren't associated with the Comanche, they didn't understand the capability. It was not a very well-articulated capability, from a TRADOC perspective. The program had been going on so long, and had so many changes to requirements, that it had time and money taken out, which forced the program to be restructured and stretched out. (R. P. Birmingham, personal communication, November 19, 2010)

Despite proactive efforts by the Comanche program office/TRADOC to arouse Army enthusiasm for Comanche, the program's condition remained somewhat fragile. Major branches within the Service, such as Armor, Infantry, and Artillery, were focusing on the completion of an FCS program that better reflected their operational perspective. Also, the flipside of the decision to transform Comanche into the "Quarterback of the Digital Battlefield" was an increasing technical risk, which further diminished the credibility of the program in the eyes of the Army and OSD. A last restructuring was directed in 2002 by the Comanche program office itself, to address this impending requirements creep. Retrospectively, however, it appeared that the program was not robust enough—in terms of relevance, constituency, and feasibility—to successfully undergo the new, major upheaval created by the GWOT.

The Second External Shock—9/11 and the Rise of U.S. Special Operations Command

Abrupt Change in Army Priorities

The Afghanistan and Iraq campaigns totally disrupted the overall Army plan to invest in long-term/high-tech capabilities for remote wars against North Korea and Serbia-like enemies. The Army was suddenly facing a low-tech enemy who was mainly using small arms, rocket propelled grenades (RPG), and improvised explosive devices. One of the most imperious needs for the U.S. Army was to possess real-time, accurate situational awareness to search and destroy the small groups of insurgents relying on cover, camouflage, and deception to mitigate the overwhelming U.S. technological advance. Comanche, whose capabilities

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were centered on the concept of gathering and disseminating tactical information, was, in a sense, relevant to this aspect of a counterinsurgency operational environment (T. E. White, personal communication, June 23, 2011). But the high-tech/high-cost design of the aircraft only offered superfluous capabilities. The light-weight composite armor (on which the contractors experienced tremendous design difficulties) was ill-suited to protect the aircraft against 12.5 or 20mm rounds (R. P. Birmingham, personal communication, November 19, 2010), while the survivability of the tougher Apache was challenged by small arms and RPGs (O'Hanlon, 2005, pp. 88–89). Comanche was caught in the midst of a collision between the Army's plan for lighter, high-tech forces that emphasized deep-strike, and the urgent operational need for more robust materials in close-combat environments.

This wartime mismatch would have been theoretically enough of a rationale to swiftly cancel the program. But up until 2003, two major elements were still shielding the Comanche from cancellation. For one thing, the program had been secured into the "Objective Force" vision, and was consequently benefiting from the official endorsement of the Army's highest leader—Shinseki. Moreover, OSD's lack of enthusiasm for the Comanche was self-constrained by its reluctance to further damage its relationship with the Army in leading the termination of another program (M. W. Wynne, personal communication, June 6, 2011). After having abruptly enforced the Crusader self-propelled howitzer cancellation in May 2002, Rumsfeld's team was indeed rather disposed to take a half-measure on Comanche, by cornering the program into a niche capability with a reduced quantity (650, as reflected in the 2002 restructure). Further decisions regarding the RAH-66 were thus delegated to the Army civilian leadership, which was still committed to field the rotorcraft, despite serious concerns on cost and risk mitigation (T. E. White, personal communication, June 23, 2011).

Final Stroke—Shift in Leadership and Operational Perspective

The strong incentive for change came in 2003 when Schoomaker stepped in to replace Shinseki as the new Chief of Staff of the Army. The appointment of a former Special Forces operative as the Army's highest ranking officer reflected the strong inclination of the Secretary of Defense for the Special Forces' operational perspective. USSOCOM (U.S. Special Operations Command) warfare concepts were widely compatible with the Rumsfeld vision of a much smaller, highly specialized, relatively low-tech Army—an idea that was in essence far different from Shinseki's plan, which was still massively relying on large armored forces (Herspring, 2005, pp. 394–395). Favored by the Secretary of Defense, USSOCOM and the U.S. Army Special Operations Command (USASOC) were rapidly gaining thrust in terms of war planning and resources allocation since the early successes of Operation Enduring Freedom (Herspring, 2008, pp. 57–58). For the Comanche program office, Schoomaker's nomination by Rumsfeld was a serious concern. For years, the aircraft had been carefully designed to fit into Shinseki's "Objective Force" by evolving to become the central ISR platform for conventional armored, infantry, artillery, and aviation units. Therefore, little had been done to accommodate the less orthodox requirements of USSOCOM/USASOC for helicopters, which favored short-term development programs, proven and modifiable airframes (CH-47, UH-60, and OH-6), long endurance (Comanche had a 300-gallon fuel tank and no refuel probe), and troop-carrying ability. As a consequence, the Special Operations community was one of the least interested in Comanche capabilities (R. P. Birmingham, personal communication, November 19, 2010).

The aircraft was threatened by an unprecedented coalition formed between OSD and the Army leadership. Before Schoomaker's nomination, the support of Shinseki (and before him, Chiefs of Staff of the Army Gordon Sullivan and Dennis Reimer), who all envisioned Comanche as a needed capability in the Army modernization effort, effectively sheltered the program from OSD's and other Army components' increasing skepticism during an entire decade. But the loss of the Chief's commitment was now leaving an open door to the detractors inside and outside the Army, who underscored the prevailing thought that Comanche was too expensive for the Army to procure. The current GWOT was further adding some consistency to their arguments. On the budgetary side, the Army was indeed struggling with two conflicts that necessitated reorganizing its funding allocations. The situation was especially tense for Army Aviation, where upgrades to the current fleet were becoming imperious in the wake of its wartime necessities (C. M. Bolton, personal communication, November 23, 2010). With a $32 million price tag per unit, Comanche was by far the most expensive program in the Aviation budget, and consequently the greatest obstacle for improving the aging fleet that was fighting in Iraq and Afghanistan. On the technical side, the Army Vice Chief of Staff, after having flown the Comanche in 2003, raised serious concerns to the USD(AT&L) over the maintainability of the aircraft on the field, due to the extensive use of stealth coating (M. W.

Wynne, personal communication, June 6, 2011). This observation was a grave impediment to the aircraft, as the top-to-bottom review of Army Aviation capability ordered by Schoomaker in September 2003 specifically calling for a "shortened logistics tail" (U.S. Senate Committee, 2004, p. 132). Although the Vice Chief publicly affirmed that Comanche was "absolutely the best flying helicopter the industry ever built for us" (U.S. Senate Committee, 2004, p. 155), the program was regarded by a vast majority of Aviation operators as an expensive, yet superfluous warfighting capability (C. M. Bolton, personal communication, November 23, 2010). Now that the Army leadership was willing to lower its guard on Comanche, OSD was in a favorable position to push its preferences and to cut a deal with the Service: Unlike the Crusader, the Army this time would ultimately enforce the Comanche termination and, in return, the Pentagon and the President would allow the $14 billion to stay within the Aviation budget (M. W. Wynne, personal communication, June 6, 2011). The Army agreed, and the Comanche was officially terminated in February 2004.

Conclusions

Retrospectively, the Comanche would appear an ill-fated program that had been gradually undermined by two significant and unexpected strategic shifts. The first external shock was the end of the Cold War, which seriously impeded the need to urgently field, in vast numbers, a stealth SCAT helicopter. Orphaned of an indisputable purpose, the program languished in its Dem/Val phase during most of the 1990s. The Army's effort toward "digitization" opened a window of opportunity for the aircraft that briefly renewed its relevance in the early 2000s until the requirements for the GWOT, which called for better survivability, finally struck the program its death blow. But the Comanche had not been the only program dubbed as a "Cold War relic" during the last decade. The F-22A was and continues to be widely criticized for the unsuitability of its requirements to fight today's war. But the outcome for the two programs diverged: The Raptor was finally truncated to 187 units, while the Comanche suffered pure termination. The difference can be explained by the support the two programs enjoyed within their respective Service. Each time OSD and Congress raised serious questions about cost, schedule, and performance of the F-22A, they faced a resolute and resilient coalition formed between Air Force civilian management, military leadership, and pilots, all of whom knew the aircraft intimately and consistently closed ranks to defend it (J. G. Roche, personal communication, June 17, 2011). While the Raptor benefited over time from a die-hard constituency, the Comanche only sporadically enjoyed the Army's commitment when its capabilities were challenged by the alteration of the strategic landscape. This can be explained by the comparatively weak institutional position of the Aviation branch within the Army, the intra-Service competition with other programs (notably FCS), and a perceived disinterest in Comanche, which over time forced the Comanche program office and TRADOC to transform the program into an all-inclusive ISR platform to secure an incontestable role for the helicopter. But Comanche's constituency had remained so fragile within the Army that it only took the departure of Shinseki—last and most highly ranked supporter of the aircraft—to doom the program. The merger that followed of Army and OSD operational perspectives, which took place when Schoomaker became Chief of Staff of the Army, was the final stroke that killed the program.

One may be tempted to explain Comanche's fate through the rational framework of cost effectiveness, claiming the advent of the Unmanned Aerial Vehicles (UAV)—which have proven their capability to efficiently perform the reconnaissance mission at a much lower cost—was the strong incentive that led the Army toward the decision to terminate the stealth helicopter (De Durand, 2003, p. 22). But interviews conducted with DoD and Army key players refuted this assumption. The aircraft had not been the unfortunate victim of an emerging "disruptive technology" (Christensen, 2000, pp. 69–88). Rather, civilian and military actors pointed out that the value of UAVs, which were in 2004 at a primitive stage, had been fully understood by the Army *after* the decision to abort the RAH-66 (C. M. Bolton, personal communication, November 23, 2010). Instead of simply looking at Comanche's cancellation in the framework of a cost/benefit analysis, this article invites Defense Acquisition Workforce students and practitioners to understand weapons programs' development as a highly dynamic political process, where a given Service's support is *not* a settled postulate, but rather a core variable that can explain termination.

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Professional Reading List

The Defense Acquisition Professional Reading List is intended to enrich the knowledge and understanding of the civilian, military, contractor, and industrial workforce who participate in the entire defense acquisition enterprise. These book reviews/recommendations are designed to complement the education and training that are vital to developing the essential competencies and skills required of the Defense Acquisition Workforce. Each issue of the *Defense Acquisition Research Journal (ARJ)* will contain one or more reviews of suggested books, with more available on the *ARJ* website.

We encourage *ARJ* readers to submit reviews of books they believe should be required reading for the defense acquisition professional. The reviews should be 400 words or fewer, describe the book and its major ideas, and explain its relevance to defense acquisition. Please send your reviews to the Managing Editor, *Defense Acquisition Research Journal*: *Norene.Fagan-Blanch@dau.mil.*

Featured Book

Rearming for the Cold War, 1945-1960

Author(s):
Elliott V. Converse III

Publisher:
Historical Office, Office of the Secretary of Defense

Copyright Date:
2012

Available Online:
http://history.defense.gov

Hard/Softcover:
Hardcover, 781 pages

Reviewed by:
Dr. Roy Wood, Dean, Defense Systems Management College, DAU

Review:

If Dickens were to have written about the years following World War II, he might have started this tome, "It was the best of times; it was the worst of times." It was certainly the best of times. The United States and its Allies had just waged a war against global domination and won, liberating Europe and the Pacific from aggression and devastation. Economies were on the mend and diplomacy again took center stage. Yet, it was also the worst of times. The Soviet Union had just cordoned off much of Eastern Europe behind an "Iron Curtain" and aimed nuclear-tipped missiles at its former allies.

It is within this context that Elliott Converse chronicles the evolution of the U.S. military from waging the largest and most deadly war in history to managing a tense and competitive "Cold War." As the title suggests, Converse focuses on America's efforts to rearm and modernize its arsenal in the face of this new and dangerous threat. The author tells an engaging story of the rapid emergence of technology and how a wartime bureaucracy was transformed and reengineered to acquire advanced missiles, aircraft, computers, and of course, nuclear energy and weapons.

At its heart, however, is the compelling story of the people who led this transformation. There are familiar players, like Vannevar Bush, James Forrestal, and Hoyt Vandenberg. But there are also intriguing stories of lesser know, but no less influential bureaucrats, including Wilfred McNeil, Clay Bedford, and Walter Whitman.

This is a well-researched and engaging book. The author captures the human side of the story through liberal use of quotes and good storytelling to get at why and how important decisions were made. In the process, Converse explores Service rivalries, budget battles, high-stakes intrigue, and behind-the-scenes dealing – and sometimes double-dealing – within Washington's halls of power. The book is richly footnoted and laced with data charts, tables, period photographs, and biographical sketches of many of the key players.

This book is of particular importance to today's defense acquisition community because it explores our roots. Many of the decisions and actions from this time period are still evident in the organization and processes we use today. Sir Winston Churchill once noted, "Those who fail to learn from history are doomed to repeat it." Through the clear lens of hindsight, therefore, we should read this book and learn from the brilliant successes and sad foibles of those who came before us.

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If you are interested, contact the Defense ARJ managing editor ***(DefenseARJ@dau.mil)*** *and provide contact information and a brief description of your article. Please visit the guidelines for authors at* ***http://www1.dau.mil/pubs/arq/arqart.asp.***

Defense ARJ

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Research involves the creation of new knowledge. This generally requires using material from primary sources, including program documents, policy papers, memoranda, surveys, interviews, etc. Articles are characterized by a systematic inquiry into a subject to discover/revise facts or theories with the possibility of influencing the development of acquisition policy and/or process.

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Defense ARJ
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Due Date	Publication Date
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