Defense AT&L

September–October 2011

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SPECIAL ISSUE

Better Buying Power

Experts from a range of acquisition disciplines discuss getting the most out of every taxpayer dollar.

- Systems Engineering
- Test and Evaluation
- Manufacturing
- International Programs
- More

Insights from:

- Under Secretary of Defense (AT&L) Ashton Carter, Ph.D.
- Principal Deputy Under Secretary of Defense (AT&L) Frank Kendall
- DAU President Katrina McFarland
- DAU Faculty
- Other Acquisition Experts

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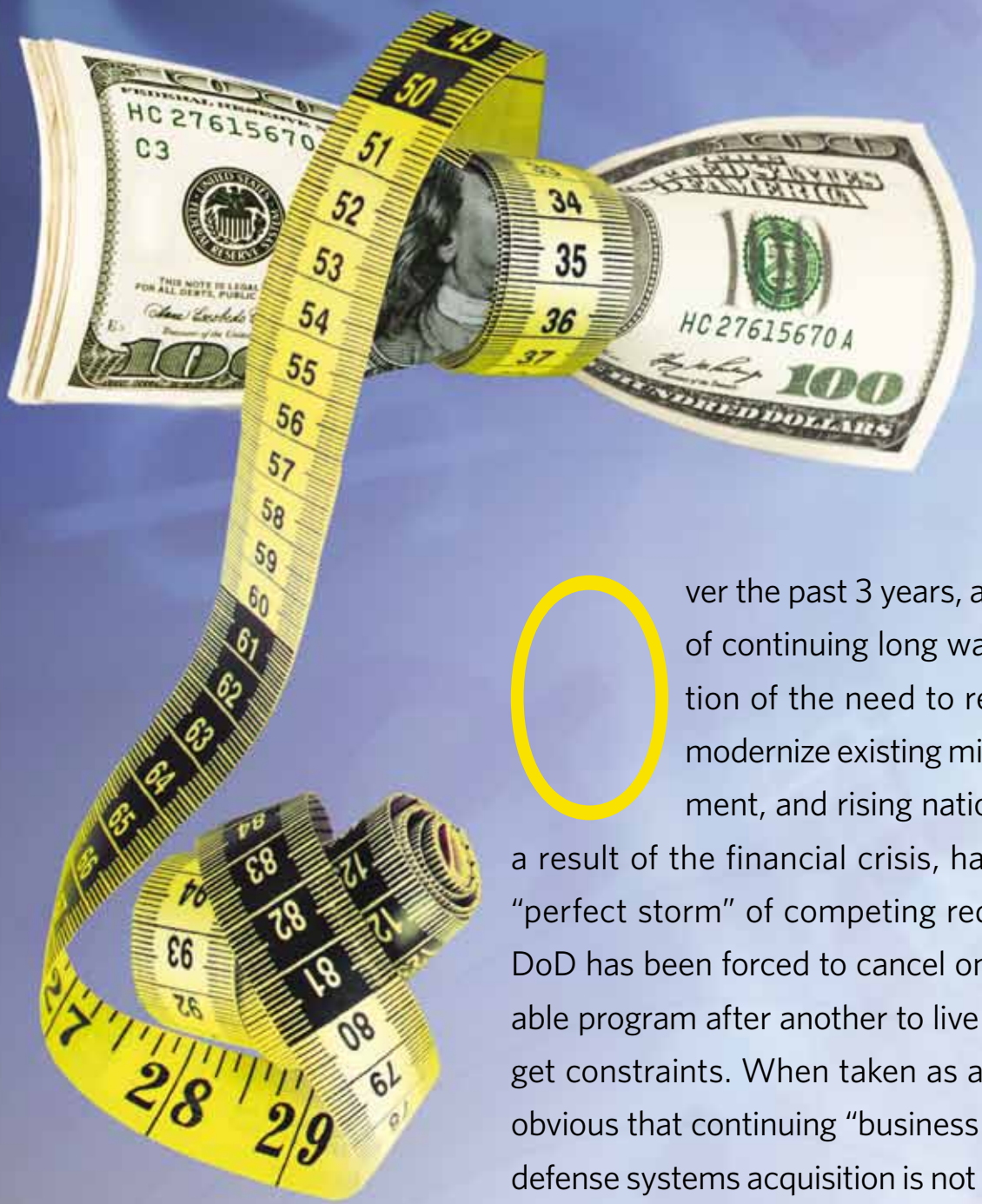
SPECIAL ISSUE

Better Buying Power

Foreword

Frank Kendall

Principal Deputy Under Secretary of Defense (Acquisition, Technology, and Logistics)



Over the past 3 years, a confluence of continuing long wars, recognition of the need to recapitalize/modernize existing military equipment, and rising national debt as a result of the financial crisis, has created a "perfect storm" of competing requirements. DoD has been forced to cancel one unaffordable program after another to live within budget constraints. When taken as a whole, it is obvious that continuing "business as usual" in defense systems acquisition is not sustainable.

In fact, upon our analysis, we noted that, as compared to the commercial world, where prices decline over time even as technology improves, our products are steadily increasing in cost, often by wide margins. DoD's productivity, its ability to deliver more without more, is going in the wrong direction when we can least afford it.

As a corps of acquisition professionals, our buying strategies must adapt to this new reality and recognize that the costs of our weapon systems must assume a more prominent role in the decision process; our nation's future depends on it. These adjustments in our acquisition approach, tools, techniques, and attitudes are necessary if we are to continue to provide our fighting forces with the material and technical edge required for victory on our terms. It is in this spirit that Dr. Carter released our Better Buying Power (BBP) initiatives and directives in concert with the component acquisition executives (CAEs).

These initiatives resulted from actively seeking inputs from acquisition leaders within DoD and the defense industry and distilled from best practices and lessons learned. More than 130 recommendations were received, analyzed, and vetted, resulting in 23 specific actions contained in the Sept. 14, 2010 Memorandum for Acquisition Professionals. These actions were grouped into five major areas:

- Target Affordability and Control Cost Growth
- Incentivize Productivity and Innovation in Industry
- Promote Real Competition
- Improve Tradecraft in Services Acquisition
- Reduce Non-Productive Processes and Bureaucracy

As acquisition professionals, you will quickly recognize that these activities fall within the existent framework of our acquisition guidance. Pursuit of affordable solutions has always been an objective in our acquisition system and these initiatives seek to further emphasize use of proven best practices for improving acquisition outcomes. The real challenge and ultimate measure of our success is the ability to incorporate these initiatives into the culture of our factories, labs, depots, test ranges, and program offices. For this we require your help.

The implementation of the BBP will not be without its challenges, and one of the biggest challenges is communicating our intent effectively so that the workforce understands how to react to the guidance. One thing we have tried hard to communicate is that our guidance is just that—guidance. It is not a set of ironclad rules that have to be followed in every case. We expect our professional workforce to use its knowledge and experience to do the right thing. For every policy we have announced there are certain to be exceptions and we have delegated the authority to make exceptions to CAEs for all of the BBP policies.

As Dr. Carter and I have interacted with various DoD acquisition offices over the past year, discussing the BBP initiatives, we have been encouraged by the willingness of the government and contractor workforce to make a difference. In the feedback that we have received, we have heard a number of repeated questions about a few of the initiatives and it has been clear that there are misperceptions about some of the guidance in some cases. The articles in this edition of *Defense AT&L* magazine will help answer some of those questions. I would like to point out three interpretations of Dr. Carter's guidance that are NOT correct.

The objective of BBP is NOT to reduce contractor profits to make programs more affordable. Absolutely not. The intent of the BBP is not to reduce the contractor's profit margins. In fact, DoD will accept *increased* profit margins if the contractor can reduce overall program price. In fact, one of the tenets of the fixed price incentive fee (FPIF) contract is to provide contractors an additional profit incentive to drive out program costs. The converse should also be true, however. We should not reward poor performance by industry with high margins, and we should use strong incentives to motivate contractor performance wherever possible.

FPIF contracts are NOT the only acceptable contracting approach. Appropriate contract types should be commensurate with program risks, and associated incentives should be based on objective criteria and tied to contractor performance. Cost-type contracts may be appropriate for efforts where there is a level of uncertainty or risk in the requirements, technology, process, cost, or outcome, such as new development. However, for low-risk programs in the Engineering and Manufacturing Development phase and for most programs in production, where products and processes are well understood, FPIF contracts can be very effective in incentivizing cost control and productivity growth. Indeed, FPIF contracts have benefits over both cost-plus contracts and firm fixed price contracts in this regard. Similar arguments can be made for using FPIF for well-understood knowledge services contracts. Incentivizing industry by sharing the benefits of cost reductions is a powerful tool for the program manager to drive out costs when used in appropriate situations.

A new affordability Key Performance Parameter (KPP) will NOT be mandated on all programs at this time, but affordability constraints will be imposed by CAEs and USD (AT&L). An affordability target will be agreed upon at Milestone A based on long-term budget analysis of the portfolio the product will be part of (ships, for example). Prior to Milestone B, a thorough analysis of significant cost and schedule drivers must be made, considering trade-offs against performance, in order to understand and drive toward affordable options. At

The implementation of the BBP will not be without its challenges, and one of the biggest challenges is communicating our intent effectively so that the workforce understands how to react to the guidance.

Milestone B, the results of these trade-off studies will be used to set an affordability "requirement" that the PM must manage to for the duration of the program. This is similar to a KPP and equally binding on the program. Affordability constraints will be defined for both production and sustainment costs.

Affordability extends well beyond the initial acquisition. For that reason, a life cycle view of every program is taken at every milestone review. Designing systems to reduce costs over the entire life cycle involves an orchestration of technology development, system engineering, logistics, and testing. To highlight the importance of this, I asked the professors at the Defense Acquisition University to examine a variety of these acquisition topics to provide additional best practices and examples of success on improving affordability within acquisition programs. This issue is dedicated to helping the acquisition workforce with practical applications of improving affordability. Hopefully, you will find many golden nuggets in this issue that will help you with your program, but my real intent is to inspire you to think about opportunities to improve affordability within your own programs.

For our community to meet the challenges the department faces, we need to bring all our talents and efforts to bear to ensure that each dollar we spend provides the best possible outcome for our warfighter and our fellow taxpayers. I look forward to your ideas, initiatives, and innovative solutions. I am confident that together, we will succeed.

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DAU

INTERVIEW

DAU President Katrina McFarland

Under Secretary of Defense Dr. Ashton Carter's September 2010 memorandum on Better Buying Power has given the Defense Acquisition Workforce a new challenge in making the most of taxpayer dollars. In an interview with *Defense AT&L*, DAU President Katrina McFarland discussed what this means for DAU and for everyone involved in buying products and services for the Department of Defense.

Defense AT&L: Could you help our readers understand the context for Dr. Carter's Better Buying Power initiative?

McFarland: Dr. Carter observed when he came on board that we weren't as productive as we could be. Items were costing more, not less, over time—whereas in the commercial world, prices decrease over time.

In addition, since 9/11, the Defense Acquisition Workforce had been focused on rapid procurement rather than long-term. Dr. Carter wanted to have the tools we had set aside revisited, because the business processes we'd been using quite appropriately to achieve rapid acquisition were not geared toward better business deals. In short, he wanted a better business deal for DoD.

Defense AT&L: Is there a general principle to how can we make better business deals?

McFarland: Better business deals tend to take more time. They need to have a prepared government buyer who's knowledgeable about the product and how they'll be working with industry.

So in May of last year, Dr. Carter began formulating this Better Buying Power initiative. His focus: How do we increase the buying power of the AT&L workforce, with more productivity and reduced bureaucracy? To explore those questions, he recruited the people actually involved in purchasing and contracting on behalf of DoD.

The team looked into the skills and authorities that we have to find the "long-ball hitters"—the best opportunities for improvement. From a list of more than 100 areas, they narrowed it down to the 23 in the final memo.

Defense AT&L: What difficulties have there been?

McFarland: One of the biggest impacts has been what Dr. Carter calls the "anti-efficiency activity," the Continuing Resolution Authority [CRA]. He released the memo in September 2010, and immediately thereafter came the CRA, which prevented the implementation from being as effective as it needed to be. Although we didn't have a solid start, we have had successes, such as the ground combat vehicle and the Ohio Class submarine. I think we'll have even more successes now that we aren't under a CRA that prohibits some activities.

Government really has a different driving force from what industry has; government has a responsibility to the public to protect the interest of the taxpayers. But the business partner's responsibility is to its shareholders.

Defense AT&L: Some months back, the acquisition community also received a set of initiatives from then-Secretary Gates, calling for $100 billion in savings over the next 5 years, while accommodating incremental but steady growth. How is this different from the Better Buying Power initiative, and where do these two initiatives intersect?

McFarland: When Secretary Gates began his initiative, there was confusion among some folks. Dr. Carter made it clear that his initiatives were to provide tools to give people a better understanding of business deals, with improving efficiency and productivity in mind. He had no dollar amount goal. Secretary Gates' initiative set a goal but did not come with a toolkit for achieving that goal. So Dr. Carter's initiative intersects nicely with that.

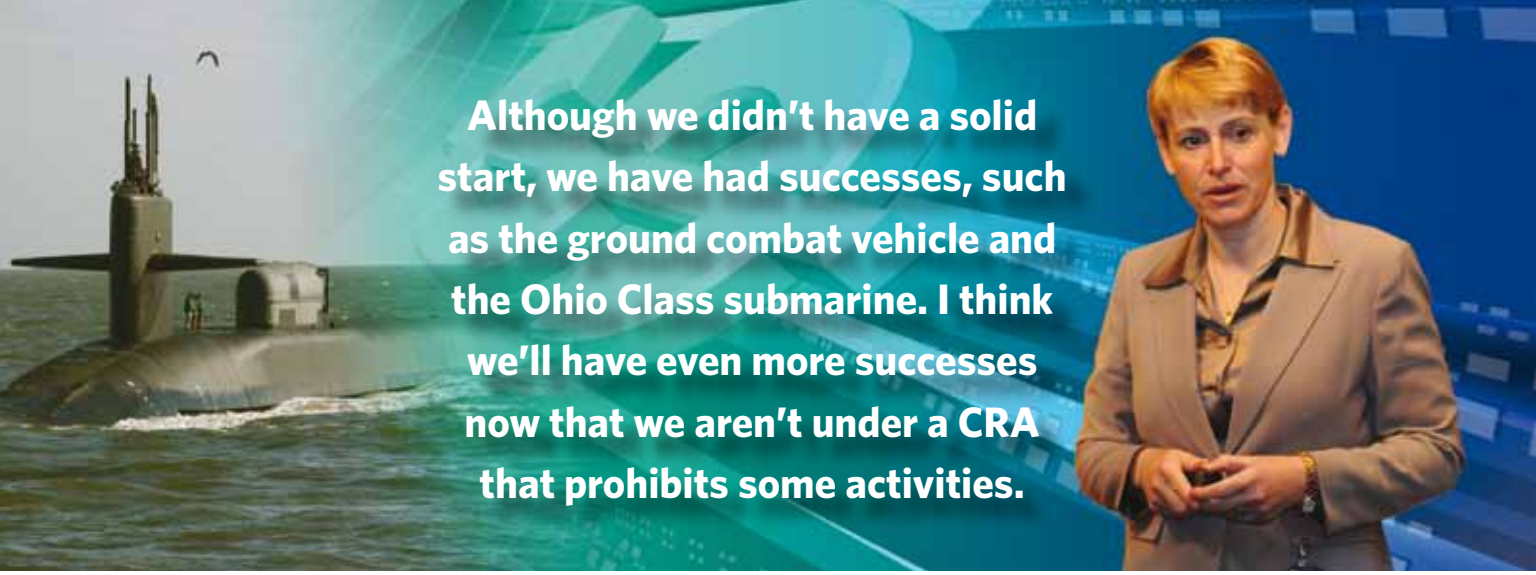
Defense AT&L: Do you think it's fair to say that the BBP initiative is more of a long-term focus?

McFarland: Yes. And that fits with the role of this university. In order to have long-term, institutional change, to ensure a principle is adopted by the larger workforce, the schoolhouse is a natural fit. And having a change in how we understand business and prepare ourselves for a business deal is a natural fit for DAU. So my role will be to help facilitate, integrate, and institutionalize these tools into our business practices and in how we train people.

Defense AT&L: What do you think DAU can do to give the workforce the tools to maximize buying power?

McFarland: The country needs a decisive capability, and it needs to be able to afford it. And that's based on value—not cheapness. And the value has to have a life cycle in mind. To do that, you have to understand how business operates. Government really has a different driving force from what industry has; government has a responsibility to the public to protect the interest of the taxpayers. But the business partner's responsibility is to its shareholders. We have to have a common understanding of how we both achieve the best outcome. So one of our challenges is to communicate with industry from a shared perspective.

One focus of DAU will be to help students to be confident in their ability to deal with industry at any point in the acquisition process. Our government people have become in-



U.S. Navy photo by Mass Communication Specialist 1st Class Kimberly Clifford

sular, because our focus since 9/11—and rightfully so—has been timely, fast, rapid get-it-out-there-quickly support to the troops. But in the current economic reality, we need to protect the interests of contingency support but advance ourselves to create better buying power where we can.

Defense AT&L: How do you see training at DAU changing to reflect this?

McFarland: I don't have an academic background. I'm a professional engineer and an acquisition executive. I first had to understand the university and how it works. I'm blessed to have some very talented and experienced staff and faculty who have helped me with this. And among faculty, staff, and customers I spoke with, there was a great deal of commonality in what everyone saw as the opportunities for how we can improve the university and take the workforce into the future.

This relates to the assignment of the Human Capital Initiatives position to be a standalone rather than combined with the University presidency, because the president has lot of work to do, and so does the whole element of HCI. In the department, we really need to focus on those. And given the volume of things to do and the need, it was a good thing to stand up the new HCI and select Keith Charles to lead it.

Between the university's next transformation and the needed transformation of human capital management, the two pieces should come together to improve our outcomes for acquisition professionals.

Defense AT&L: Could you talk a little more about that transformation?

McFarland: The university has got some of the highest accolades from commercial and academic institutions around the world. I'm surrounded by medals and awards. Yet we've gotten to the point where we need to ask: What can we do to improve? It's evident we need to improve how career management is conducted and how we train our people, both in the teaching side as well as the teaching methodology. So there's a great opportunity for the workforce to not just certify people, but people have to *qualify* in their jobs—to *demonstrate* their ability to perform what they've been taught. And this will give them more confidence in doing business.

What's occurring right now is as though your son or daughter who just turned 15 takes and passes the driving test, and then you throw keys at them before they've ever been behind the wheel in real traffic. Not quite what we want. We want to sit with them and help them learn how to drive by mentoring and coaching them. So the training at DAU needs to evolve past formal classroom training. And some of our case analysis has already migrated toward that. The next step is to do it on the job.

Another important part is career management: ensuring that the people coming here to get qualified have met the prerequisites for that—that they're at the right place, at the right time, for the right reason.

Defense AT&L: What general advice do you have for new acquisitions professionals?

McFarland: The most that you can think about in terms of one's future is: Your career is not a race to the finish line. This is a journey. If you think about the trades: You start as an apprentice and then become a journeyman and ultimately a master. Getting to the next level is not based on how much time you spend but by your mastery of specific tasks. You yourself will become more confident by having done it, and both good and bad experiences contribute to that. My advice is not to try to race to a management position, because one thing experience brings is that confidence.

So engage in doing. Find people who will mentor you. Take the learning you get in the classroom, and then go and participate in as many diverse opportunities as you can. Expand your view beyond your local program office or business office, and reach out to expose yourself to the business of acquisition. It takes time.

Systems Engineering:

the Affordability Secret Weapon

Mike Holbert

While Dr. Carter's affordability initiatives highlight the role of program managers in creating program affordability, a closer review shows a majority of program efficiencies can result from implementing program rigor through effective systems engineering, or if you prefer, systems thinking. How so?

It's the system engineering process that:

- Breaks down the requirements into understandable/actionable units for analysis, establishing system, subsystem, and component qualities and capabilities.
- Provides the analysis leading to design solutions via detailed designs and/or processes and procedures.
- Provides the analysis to make supportability decisions years before the end item is even tested.
- Identifies the technical roles and the potential solutions which become the basis for the Acquisition Strategy.
- Ensures alignment of requirements, specifications, and statement of work.
- Generates the decision-quality information to drive the effort to completion.
- Ensures an integrated and interoperable system from beginning to end.

Holbert *is a professor of program management at DAU. He has 22 years of acquisition management experience in engineering, program management and logistics management of Air Force and Joint programs.*

While I could go on about the advantages of a disciplined systems engineering approach, the real challenge is not in simply identifying how it ought to work, but in delivering affordable performance through consistent, persistent intellectual focus and action.

Common to many of the 23 affordability initiatives is the implied use of disciplined processes to enable disciplined decision making at all levels, using appropriate data. To aid this leadership/management function, there are eight systems engineering technical management processes to help provide intellectual focus and tracking of actions:

- Decision analysis: the deliberate process for making optimum decisions
- Technical planning: defining the scope of the technical effort required to develop, field, and sustain the system
- Technical assessment: the process of reviewing, analyzing, and evaluating a series of technical products to determine effectiveness in meeting the systems capability requirements
- Requirements management: assuring traceability of allocated and derived requirements to the user defined capabilities
- Risk management: identification, analysis, mitigation, and tracking of root causes that impose a probability you will not meet cost, schedule, or performance requirements
- Configuration management: identifies, documents, audits, and controls the functional and physical characteristics of the system design
- Data management: the process to acquire, access, manage, protect, and use data to support the product throughout its life
- Interface management: control measures and processes to document and communicate physical and functional attributes of a product or system

Each of these systems engineering technical management processes is further described in chapter 4 of the *Defense Acquisition Guidebook*. When properly executed, these technical management processes allow clear insight into, and control of, the technical processes used to develop and field a capability. The technical processes are espoused in the various versions of the systems engineering "Vee" model and the newer "Comprehensive Systems Engineering Process (CSEP)" model. However, a dilemma exists with any model used; models do not and cannot assure disciplined processes are executed, or disciplined decision making is followed. Sorry to say, yes, this dilemma does apply to the beloved engineering "CSEP," "Vee," the older "Engine," and even the "Affordable System Operational Effectiveness" models.

This is where the joint leadership by the program manager and systems engineer (a PM's technical conscience) must ally with each other to pre-think and pre-plan driving process and decision discipline, and thus affordability. These eight technical management processes provide the context for the rest of this discussion. They apply to the program manager and other key stakeholders, both up and down the decision chain.

Start Well by Knowing Your Destination

The purpose of any systems engineering model is to help the program manager and the program team understand activities and logical decision points as the effort progresses. Due to the structured nature of the systems engineering process and the checks and balances of the eight technical management processes, a program manager can make informed decisions at the beginning of a program and throughout its life cycle to determine which requirements lead to the greatest affordability dividends. To understand how this works, let's look at the "Hierarchical Systems Engineering Vee" model (Figure 1). In the Requirement Definition process, senior decision makers must focus on these critical questions:

- What is the capability or function of the program or product?
- How much are we willing to pay for each product, "a worth" determination?
- Is the solution "affordable?"
- Does the schedule meet the need as well as the "investment plan"?
- What is the expected level of "process conformance" by the program?

This requirements definition activity starts the systems engineering effort in development planning and arguably engages most of the eight technical management processes. To better understand the critical nature of the requirements process, and its impact on affordability, refer to Jack Mohney's article on the effective development of joint operational requirements.

As you move toward the Requirements Analysis activity, planning becomes the program manager's most critical task. Enter the systems engineer as the program manager's specific ally, along with some other close allies like their contracting officer, financial manager, logistics manager, and their human resources manager.

Personal Involvement Matters

As we survey the rest of the "Vee" by moving through the three Decomposition and Definition activities, Implementation, and the three Realization and Assessment activities, it causes us to invoke disciplined planning. This is underpinned with risk management, technical assessment, requirements management, interface management and with a critical dose of decision analysis. Four foundational documents provide the articulation, for all to see, of how you will exercise the eight technical management processes to invoke consistent, persistent intellectual focus and action. These documents are the Acquisition Strategy (AS), System Engineering Plan, Life Cycle Management Plan, and the Test and Evaluation Master Plan. Each plan should flow from the AS and expound on how the eight technical management processes will be used to deliver decision-quality data and ultimately the desired capability.

These planning documents are much too important to simply outsource or "borrow" from another document. A program manager's personal involvement will have dramatic affordability impacts—positive or negative. The program manager must chart the program course through critically constructing an AS foundation and laying out appropriate plans to execute the strategy. By doing so, the program manager moves every aspect of the program, and every person involved, in a common direction and a common rhythm.

The Play Book

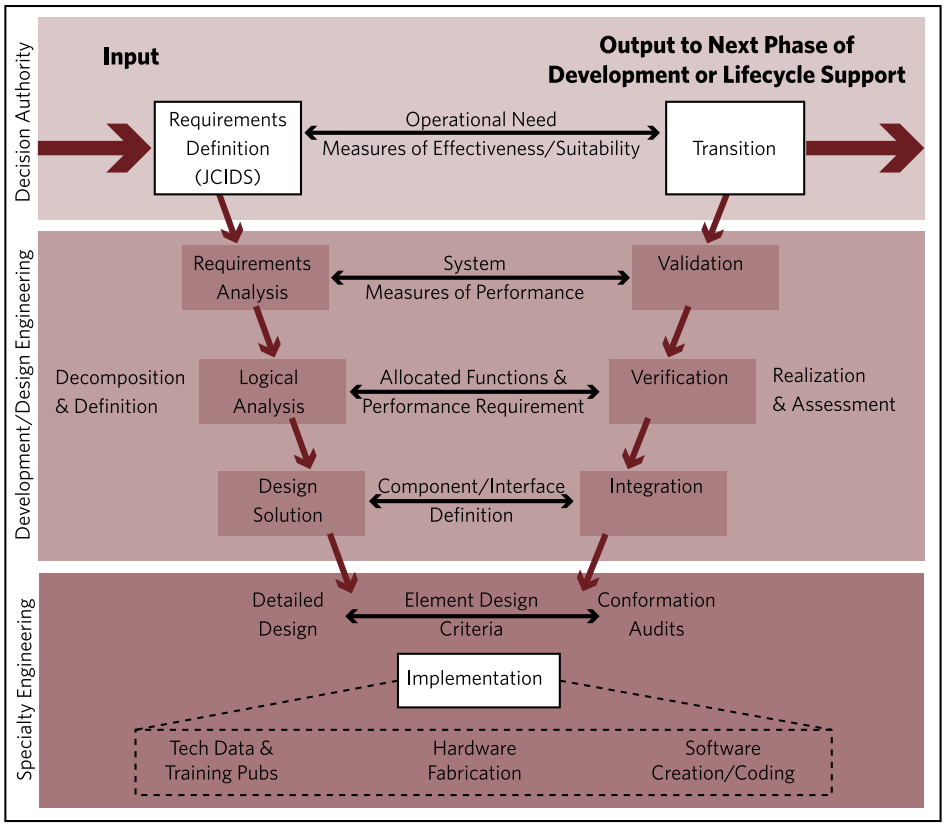
The AS is the program manager's and team's self-developed program "git-'er-done" play book and must start by answering the question: "What are the program risks based on a clear understanding of the defined requirements and concept of operations?" The trick is articulating those risks and mitigating them using the AS through:

- Describing the capability being procured and the associated risks.
- Justifying contract type(s) and associated incentives.
- Stating funding types and timing for the various types.
- Detailing conformance to agreed to processes.
- Establishing technology understanding/maturity and trade study expectations.
- Stating how the system is planned to be sustained or discarded.
- Determining how to demonstrate the product works (as the requirements have been defined).
- Including the impact of either a joint or international partner.

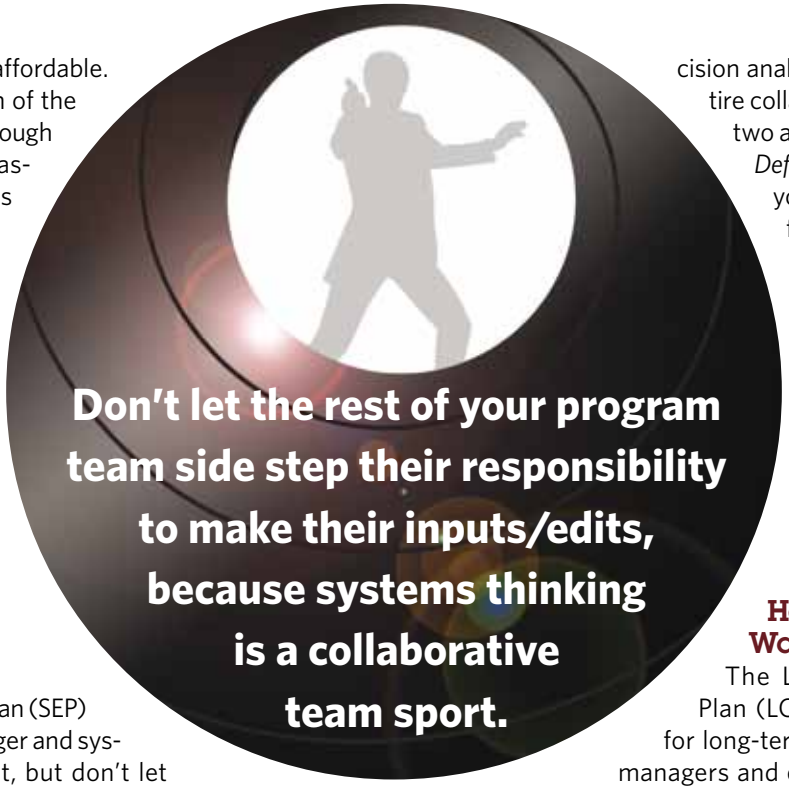
Perhaps the three most important aspects that create the overarching business strategy in your Acquisition Strategy are contract types/incentives, funding types/timing, and the integrated master plan and the associated program integrated master schedule, which may not simply be the contract schedule. To better understand the options available to the program manager in his business strategy, I refer you to the article by John Pritchard, et al., discussing how new contracting approaches impact program affordability. Affordability is and, frankly, has always been an ever-present concern, but it has for the most part been "talked around" in the AS.

So the recurring theme in planning discipline is to state clearly how each part of your AS will work to keep the total

Figure 1. Hierarchical Systems Engineering Vee



integrated program cost affordable. Be sure you address each of the topics identified here. Although you may be tempted to assume away the impacts an international partner can have on your strategy, don't ignore this potentially significant affordability driver. To get better insight into international impacts on affordability, refer to Craig Mallory's article on international programs.



How Do We Know What It Is and If It Will Work?

The System Engineering Plan (SEP) is the joint program manager and systems engineer document, but don't let the rest of your program team side step their responsibility to make their inputs/edits, because systems thinking is a collaborative team sport. This is the program manager's document outlining how he/she, along with the chief systems engineer, will invoke engineering discipline in the program and involve the entire team in delivering the required capability. This document encompasses the three Decomposition and Definition activities and the three Realization and Assessment activities and describes the processes used to connect them as depicted in Figure 1. The program manager and the chief systems engineer should:

- Lay out the clear plan for the technical architecture, the demarcation of the interfaces, and at what levels the configuration and interfaces will be managed.
- List necessary trade studies and analysis efforts.
- Describe expectations regarding engineering teams working and sharing information.
- Describe how technical progress will be assessed, including long-term performance (read sustainment, including reliability growth and maintainability improvements).
- Identify how production readiness and producibility are tracked.
- Address the approach to manage/insert new technology into the program.
- Describe staffing requirements necessary to execute this effort.

Why? Each one of these areas affects the program's affordability. But the key aspect of a SEP is the planned trade studies and analysis. Properly planning and then driving these trade studies into the program will have dramatic effects on a program's affordability decisions, through the use of decision-quality data. Understanding the direction and intent for these studies invokes a self discipline and, therefore, a program decision analysis discipline for the entire collaborative team. There are two articles in this very issue of *Defense AT&L* that might help you in your SEP writing efforts. The first is Brian Brodfuehrer's article on program metrics, to help you understand how to technically assess the program's progress, and second is a team article on effectively managing the transition to production by Dusty Schilling and Pete Czech.

How Long Do You Want to Operate?

The Life Cycle Sustainment Plan (LCSP) lays the foundation for long-term affordability. Program managers and engineers: Put your loggies/sustainers on speed dial—really. Expect engagement by your logistics manager on this plan; get those sustainer ideas on all aspects of the program. If sustainers are silent or unheard until you walk through the realization and assessment efforts, you can be sure life cycle affordability is in jeopardy.

Make sure those logistics managers bring their financial manager and contracting friends, because this plan needs good cost estimating and critical thinking about how it will be implemented in the contract and/or with organic capability. I refer you to Mark Husband's article on cost estimating. Engineers often believe a material or software solution is best, but a human process works just fine. I have generally found loggies balance these perspectives and generate more holistic and workable solutions.

By the way, did you notice at the bottom of the "Vee," under "Implementation," there are the words "Tech Data & Training Pubs" alongside "Hardware Fabrication" and "Software Creation/Coding?" Procurement of data rights for our systems can be a key to both long-term system sustainment and affordability. See Dave Gallop's article on the technical data decision process. Sure seems both engineers and loggies need to be involved through the Decomposition and Definition effort as well as through the Implementation and into the Realization and Assessment efforts. The LCSP is not just the sustainer's plan; it belongs to the program manager and the engineers as well. More importantly, it is driven by how the AS indicates the capability will be sustained across the life cycle.

Have you ever noticed how loggies and engineers think the same? Well, they generally don't. Engineers like black and white; loggies like "what abouts" and "what ifs."

The LCSP focuses engineers and loggies on a common thought: "How will this capability keep working long after we have all left the program?" And more importantly, "How will it stay sustainable and affordable throughout its expected life?" For a better understanding of sustainment, I refer you to Bill Kobren's article.

I Can Prove It

The Test and Evaluation Master Plan (TEMP) lays the foundation for a disciplined process of early and timely confirmation the capability DoD expects will work. You have heard the adage, "Bad news does not get better with time." What the unknown author really meant was, "The later you find out things don't work, the higher the ultimate price tag." Said another way, "The desired capability becomes increasingly unaffordable."

Nobody really likes to be tested, but that is exactly what moving up the right side of the systems engineering "Vee" and into the Realization and Assessment efforts does. The TEMP establishes how we will confirm to everyone involved that what is being purchased has the desired capability. The TEMP is the proverbial "Iron sharpens iron, so one man sharpens another" document. Knowing the program will be tested makes engineers and loggies do their respective tasks better. Knowing tests are resource intensive (read expensive) makes program and financial managers sharpen their funding allocations. Understanding the answers to the test questions (documented requirements) makes the requirements expectations clearer.

You did notice the horizontal lines between the three Decomposition and Definition activities and the three Realization and Assessment activities to the right? A good test and evaluation effort drives the ultimate in decision-quality data. Have I said yet the TEMP is a team document? It drives the cost by virtue of its existence and the weaknesses it finds, but it can also help confirm a program's capability and frame its affordability. For more insight into improving affordability through better testing, refer to Mike Bohn's article. A great advantage of systems engineering discipline is the early involvement by the test manager in a program.

Planning Allows Graceful Execution

All four of these documents remind every engineer in that middle part of the "Vee," the "Decomposition and Definition" as well as the "Realization and Assessment" effort, just exactly how to make decisions with cost, and thus affordability, as a foundation. They all chart the program course and/or consistently remind everyone involved in executing the program that affordability is at the forefront of each decision point along the path to delivering the product. But just as critically, they help your senior stakeholders determine if the nation's wealth is being well spent. So the next time you see the simple systems engineering "Vee" model, know it is the guide book to successful planning and execution of a program, and your secret weapon to successful delivery of an affordable capability driven by decision-quality data.

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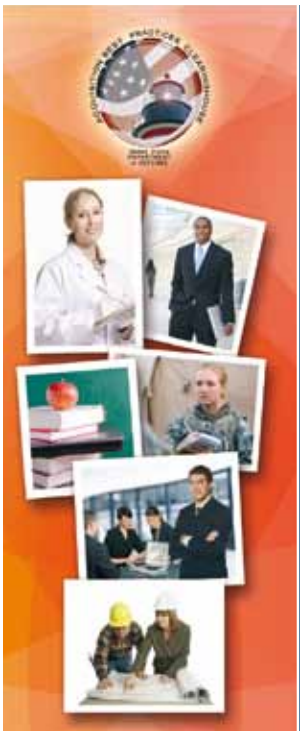

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DoD Acquisition
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A single, authoritative source of useful, validated, actionable practice information

Do these issues sound familiar?

- There are many practice lists to choose from but no guidance for selecting specific practices
- "Proof of practice" effectiveness is usually not available
- The connection between practices and specific program risks are undefined
- Success factors for practices are not well documented
- Implementation guidance is often missing
- The cost and timeliness associated with implementing and using the practices are often not specified

The BPCh can help by:

- Serving as the authoritative source for practices in DoD and industry
- Targeting the needs of the software acquisition, software development, systems engineering, program management, and logistics communities
- Connecting communities of practice, centers of excellence, academic and industry sources and practitioners
- Promoting and assisting in the selection, adoption, and effective utilization of best practices and supporting evidence

For more information, visit the BPCh web site at https://bpch.dau.mil, or contact:

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Should Cost Management: Why? How?

Under Secretary of Defense (AT&L) Ashton B. Carter, Ph.D. ■ *John Mueller*

One of the most powerful of the Better Buying Power (BBP) initiatives is the use of "should cost" management on major program acquisitions to incentivize productivity and reduce cost. At the heart of this initiative is a challenge to the business-as-usual approach, with its underlying assumption that program costs will grow to match (or exceed) the independent cost estimate. The goal of the program manager

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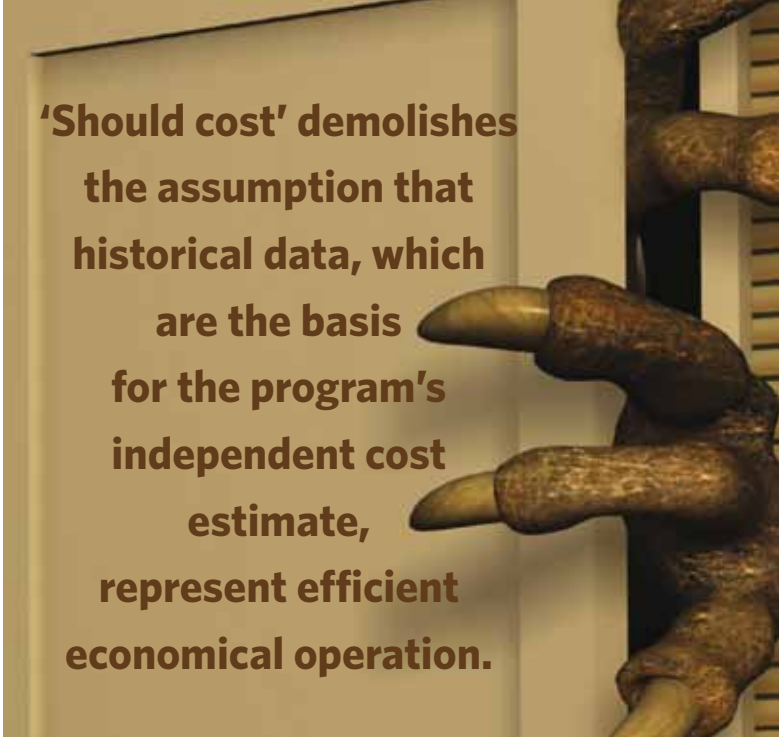
WILL
COST
SHOULD
COST

must be to challenge the inevitability of past performance by identifying and eliminating process inefficiencies and embracing cost savings opportunities. The purpose of this paper is to outline how to implement "should cost" management and describe how it can lead to more affordable programs.



Why Use 'Should Cost' Management?

The reasons to conduct a "should cost" vary from basic compliance with the AT&L initiative to zeal—"I've been waiting for years to attack program costs, and now's my chance!" Whatever the PM's reason, implementing the BBP "should cost" guidance must take a focused approach where the PM takes greater ownership of the program cost baseline to drive out costs. "Should cost" demolishes the assumption that historical data, which are the basis for the program's independent cost estimate, represent efficient economical operation. Indeed, in any given program, there are countless processes, technologies, and trade-offs that can increase efficiency, reduce unnecessary overhead, drive down risk, and bring substantial savings over historical "norms." Program management teams must work diligently to find these opportunities and build them into their program plans and cost estimates to arrive at the program should cost.

'Should Cost' Versus 'Will Cost' Mentality

Program costs are estimated in a variety of ways and by a number of organizations. The Program Office Estimate (POE) represents the PM's first calculation of the resources needed to be successful (or in some cases, the Service-level cost estimation). This is often a bottom-up engineering analysis of costs. For acquisition category (ACAT) 1D programs, the independent cost estimate, or ICE, (sometimes known as the non-advocate cost estimate) is done by the OSD Cost Assessment and Program Evaluation (CAPE) office and presented at milestone reviews. The ICE is frequently performed using analogous or parametric program data based on historical costs and formulas (cost-estimating relationships). From these estimates, the Milestone Decision Authority will establish the program's official budget.

In some way, each of these estimates builds upon past performance data to create an estimate of future program costs. Indeed, AT&L defines will cost as "reasonable extrapolations from historical experience." A common feature of all estimates is that they follow the axiom "All estimates are wrong; some estimates are more useful than others." This is not an indictment of cost estimating practitioners, who boldly attempt to predict future costs by reviewing reams of data from previous efforts.

The main problem with the will-cost estimate isn't in the numbers or how it was reached; the problem is that once the will-cost estimate is derived and the budget for the program is set, historically, this figure becomes the "floor" from which costs escalate, rather than a "ceiling" below which costs are contained—in many ways creating a self-fulfilling prophecy of budgetary excess. Therefore, it is essential that costs be controlled below the will-cost estimate, and the challenge for the PM is to be diligent in identifying productivity improvements and efficiencies to do this.

BBP "should cost" management requires the involvement of the PM and his entire team of functional experts. "Should cost" management relies on government and contractor teams that have learned from their experience with past programs and from intense scrutiny of the current program—areas where previous errors can be avoided, process efficiencies can be gained, and technical trade-offs will save money without compromising requirements. The PM must envision the program operating as it could be, rather than accept things as they always have been. The program team must embrace the view that it is to everyone's advantage to demand a higher level of performance than the status quo.

BBP 'Should Cost' Management is Not Your Father's 'Should Cost' Review

Don't confuse the current "should cost" initiative with the older Defense Federal Acquisition Regulation (DFAR)-defined "should cost" review. The DFAR review is typically undertaken when a program is entering production. This review was a manpower-intensive, in-depth review of contractor production processes and costs. A large team of engineers, production specialists, logisticians, and program managers performed the in-depth analysis.

A BBP "should cost" management approach should be used throughout the program life cycle. It is particularly focused on up-front planning and exploring engineering trades to ensure successful outcomes at every milestone. By creating cost-conscious technical and schedule baselines, identifying cost saving

engineering trade-offs, and then aggressively managing areas identified for cost savings, efficiencies can be gained throughout the program. Productivity improvements might include investing in new technologies that reduce out-year costs, finding alternative sources or technologies for high-cost components, combining developmental and operational testing, and maximizing modeling and simulation. There are no silver bullets; each PM must find solutions that fit his or her specific program. In the final analysis, embracing the "should cost" management paradigm represents a cultural change, not just a one-time event.

Initiating 'Should Cost' Management

The Sept. 14, 2010 Better Buying Power memorandum reads in part:

> I will require the manager of each major program to conduct a "should cost" analysis justifying each element of program cost and showing how it is improving year by year or meeting other relevant benchmarks for value.

As you begin your initial "should cost" analysis, gather your program's functional leaders together to perform an end-to-end review of the program. Question assumptions. Ask probing and perhaps uncomfortable questions, such as:

- Are the current program requirements still valid? Is engineering trade space available? What technical aspects of the program appear to be driving costs? Do alternative technologies or processes exist, and what are the potential savings?
- Is the program structured and resourced properly? What changes to organization, processes, schedule, or budget profile would make the program more efficient?
- What government activities, processes, or bureaucracy drive costs? Are these actions necessary for program success or risk mitigation? Can they be waived, modified, or eliminated?
- Can modifications to the contract be made to help the contractor improve efficiencies?
- What data or deliverables are we requesting from the contractor? What individual or organization uses these? Are they useful and necessary?

Frequently, as programs mature, requirements, processes, data, and priorities become routine and habitual. Fundamental assumptions need to be questioned. This sort of "spring cleaning" for your program can be a ready source of substantial "low hanging fruit" savings. Additionally, challenge your production assumptions; quantities and rates could have been established more to fit into a now outdated budget profile rather than to minimize your production costs. Hold as many of these discussions jointly with your contractors and seek their ideas and inputs. This will not only demonstrate commitment to affordability, but make the follow-on reviews of contractor activities easier.

Because you are trying to identify savings across all processes, it is crucial that you attack the "should cost" analysis with your entire team. You need to be dedicated and persistent, and you must approach the task with urgency. Remember: You are trying to change the status quo, and there will be resistance to that change. Be prepared. Your goal should be to identify the "should cost" savings candidates, get the required changes into your program baseline as quickly as possible, and then execute smartly so you do not lose the opportunity to cash in on these savings.

The 'Should Cost' Management Team

To reiterate a key point: Your "should cost" management team must include members with broad cross-functional experience; "should cost" is NOT a strictly business function (contracting and financial management). Remember, your team's objective is not to further refine an estimate, but to examine the program's technical and programmatic assumptions and make deliberate changes to reduce costs. To be successful, the team must include engineers and technical experts who can spot design or industrial process changes. It must include business and contracting experts who know where the money is. Participants from the Defense Contract Management Agency (DCMA) representative office in your contractor's facilities can be valuable members of the team, as well. You should also invite representation from your requirements shop to help adjudicate the impacts of technical trade-offs on operational capability.

The Sense of Urgency

Undertaking "should cost" management is not to be taken lightly or impulsively. A key element to success is to create a sense of urgency on both the government and contractor team. Given the current pressures on the DoD budget, it should be clear that programs that do not perform or are not affordable are at risk of being canceled or curtailed. However, a good "should cost" analysis and management plan also requires time to do right. Striking the right balance between urgent and deliberate will be key. Obviously, starting as soon as possible will allow you to finish sooner—so do not delay. Also, remember that managing to "should cost" is a long-term endeavor. You are unlikely to find all the potential cost savings in your first analysis. In the final analysis, it is highly unlikely that anyone will criticize you for coming in with additional cost savings at any time!

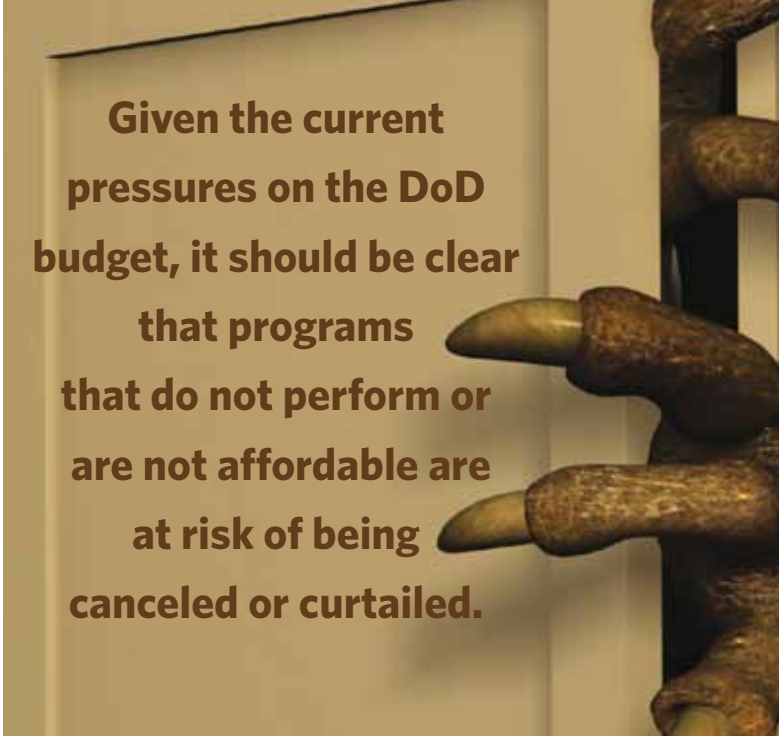
Objectives for 'Should Cost' Management

Remember, the primary objective of "should cost" management is to find efficiencies and savings opportunities. There are many ways that the team can achieve this end, but frequently they are divided into overhead costs and direct program costs. This is sound in theory but challenging in practice, because "one person's efficiency is another person's paycheck." The following approach may be useful in initiating your effort:

- **Scrutinize every element of program cost:** Start with the big-ticket items in your program. You may be able to create a Pareto chart of your program cost drivers as a way to prioritize your efforts. Question assumptions about requirements, technologies, and processes. Some of these may have been put in place years ago and be outdated. Given your time

pressures and limited resources, identifying one or two big cost savings opportunities can be like striking gold. Work your way down through the smaller changes, which—over time—can add up to significant savings.

- **Look for savings in repetitive activities:** Over time, repetitive processes can become habitual and self-sustaining, even when the need has long gone away. Question the reasons you should create a "routine" report. Analyze how you could reduce the time or staff required to work on a repetitive task. Ask why so many people attend various meetings. Call in the assistance of Lean Six-Sigma experts to assess your processes and trim the fat. Encourage your contractors to similarly self-evaluate and jointly look at inefficiencies in processes you engage in together.
- **Leverage learning curves:** Repetitive tasks, particularly in manufacturing, benefit from the "learning curve." Theory says that the initial items on an assembly line take longer to build and cost more than subsequent items because early mistakes are discovered, items are reworked, and processes are refined. Check your cost estimates for your production lots and see if they include credit for the learning curve effect. (Learning-curve benefit is frequently cited as a percentage decrease in unit price for every doubling of the quantity produced). Caution: work to minimize changes in the product or process; if you have to start over producing a "different" item, the learning curve is "reset," and you lose the cost savings benefits for a time. Frequent changes essentially nullify the learning curve, and costs will remain higher than they need to. So be judicious and intentional about production changes. Learning curves are a powerful tool in reducing the price per unit, and a small percentage decrease can have a large cost impact for program producing a large number of units.
- **Examine overhead and indirect costs:** Frequently viewed as secondary when compared to the direct program costs, many cost teams look to overhead accounts for low risk efficiencies. A routine review of invoices to verify that these costs are "reasonable and allowable" may find items that are negotiable and will save the program money. A more thorough review of contractor overhead costs is a complex undertaking requiring insight into corporate structures, business assumptions, and subcontractor arrangements. It will likely require time and a trained audit team and should probably be undertaken only if you have reason to believe the costs are out of line. Note that even if you are successful in having some overhead costs shifted off your program, these costs may have to be absorbed by other government programs dealing with the same contractor rather than resulting in actual enterprise-wide savings.
- **Incentivize your contractor on cost savings:** Creating a win-win situation for the government and contractor can be the most significant cost cutting tool. If properly incentivized, the contractor has the best chance of reducing costs since they have greater engineering and business insight into the actual design and manufacturing processes of the program. The government PM has a wide range of possible incentives ranging from improving cash flow, to higher fees or profit when the price to the government is reduced.



The objective of "should cost" management is to smartly reduce the cost of defense equipment and services to the taxpayer. "Should cost" savings are not arbitrary ("Everyone takes a 10-percent cut"), or a challenge to the PM to play "liar's poker" ("I can bring this baby in for a billion dollars under the ICE, by golly!"). Every identified "should cost" savings opportunity must be tied to a specific engineering or business change that can be quantified and tracked. PMs should have a good analysis to show the proof of a potential savings, the associated consequences and/or risks, and a viable alternative or "off ramp" in the event the change or savings cannot be realized. Likewise, program teams should try to anticipate longer-term unintended consequences that may result from short-term savings strategies like reducing test hours or inspections. The PM's team should take the longer view and balance cost savings and total program success—delivering for the warfighter. The objective of "should cost" management is making smart changes that result in better outcomes.

Final Words

"Should cost" management is doing the right thing for our programs, the warfighter, our suppliers, and our nation. It will not be simple or easy. It is not a one-time fix but a change in the culture of our government teams and our contractors. And failure is not an option.

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Requirements in the Affordability Crosshairs

Jack D. Mohney

Warfighter capability. System requirement. Affordability. Between recent congressional direction, GAO reports, defense media pundits, DoD symposia, and a number of recent *Defense AT&L* articles, each has received more than its share of the limelight. During the semi-annual Program Manager's Forum

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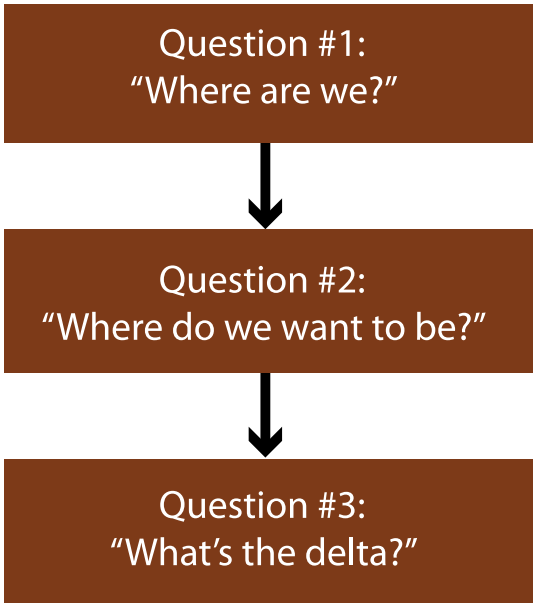
hosted by DAU, over 20 major DoD PMs identify and rank their major issues and then provide a briefing to AT&L leaders. Since 2007, each briefing has listed some form of the term "requirements" in the top seven issues—usually in the top three. In fact, for the last two PM Forums (November 2010 and June 2011), the outbriefings listed "Requirements & Testing" as the no. 1 issue.

Combine this perception with President Obama's goal of cutting DoD by nearly $400 billion over the next 12 years, Secretary Panetta's goal of restructuring the DoD to save that amount while still protecting national security, and Dr. Carter's Better Buying Power initiatives. The result presents those of us in the requirements and acquisition communities with a prime opportunity to address long-standing process disconnects, thus improving the materiel solutions our warfighters use in battle while giving ourselves—the taxpayers—a needed cost break. The key is "Problem Solving 101"—analyzing our situation and asking three central questions:

Figure 1. The Three Questions



Question One: "Where are we?"

What exactly is a "requirement"? Merriam-Webster defines the term "requirement" simply as "something essential to the existence or occurrence of something else." However, we in the DoD corporate structure often use this term to arbitrarily describe anything from a nuclear deterrent characteristic to a battlefield mission task to a contractual specification. For years, this "semantic imprecision" has led to confusion within the requirements, acquisition, and resourcing communities. Aside from the Joint Capability Areas (JCAs) —DoD's method to describe military capabilities—there is little common usage. Thus, for purposes of this article only, let's develop a meaningful lexicon using working definitions synthesized from a number of disparate sources. (See sidebar this page.)

Working Definitions of Requirements-Related Terms

Capability: The ability to achieve a desired objective in a military operation that supports national security under specified standards and conditions. Normally involves identifying wartime tasks, conditions, and standards.

Operational Requirement: A warfighter-defined and validated qualitative and quantitative parameter that specifies a needed capability and serves as a basis to define operational effectiveness and suitability—traceable to a capability.

Derived Requirement: A parameter not explicitly stated but derived through requirements analysis. It can result in DoD terms like Key Performance Parameters (KPPs) and Key System Attributes (KSAs) and is traceable to an operational requirement.

KPP, Key Performance Parameter: A quantitative system attribute the warfighter considers critical to the development of an effective military capability—observable, measurable, testable, and traceable to a derived requirement.

KSA, Key System Attribute: A quantitative system attribute the warfighter considers crucial to achieving a capability solution, but not as critical as a KPP—also observable, measurable, testable, and traceable to a derived requirement or KPP.

MOE, Measure of Effectiveness: A mission-oriented qualitative or quantitative measure of operational success closely related to the objective of the mission or operation being evaluated. MOEs are linked to the future testing of the system and often traceable to the Analysis of Alternatives (AoA).

MOP, Measure of Performance: A system-oriented quantitative measure of a system characteristic (e.g., range, velocity, mass, scan rate, weapon load-out, etc.) chosen to enable calculation of one or more MOEs. MOPs are also linked to future testing of the system and are traceable to MOEs.

Technical Requirement: A characteristic that the acquisition community can translate into a system specification that eventually goes on contract—traceable to a KPP or KSA.

Specification: A document the government can use to communicate to industry that characterizes the nature of the material, hardware, software, or service—traceable to a technical requirement.

What is the current mechanism of requirements development? Next, we need to briefly examine the governance that prescribes how DoD identifies warfighter capabilities and translates them into operational and derived requirements. In 2003, DoD issued Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170 to implement the Joint Capability Integration Development System (JCIDS) with the goal of advancing capability analysis, improving operational requirements development, and promoting joint solutions to wartime problems. The current version is CJSCI 3170.01G; however, this guidance is changing.

What's the current status of JCIDS? "We're starting to rewrite JCIDS. It has been gamed to death and we're going to throw it away," said U.S. Marine Corps Gen. James Cartwright, vice chairman of the Joint Chiefs of Staff, at the April 14, 2011, National Space Symposium. "We're going to try to align ourselves with acquisition and three levels of risk. As we stand down Joint Forces Command, we will move that function into the J-7 of the Joint Staff. And we will align J8 and J-7. The J8 will be material solutions, J-7 will be non-material solutions. The two offices will work together under auspices of the vice chairman of the JCS."

Specifically, to address these and other shortcomings in capabilities analysis and requirements development, the Joint Staff's Force Structure, Resources, and Assessment Directorate, J8, formally chartered a Joint Capability Development Process Review (JCDPR) on Sept. 9, 2010 to:

> "...review the JCIDS and provide recommendations to improve the process's responsiveness and decision support to the Joint Requirements Oversight Council (JROC), COCOMs, Services, and Defense Agencies/Components... The process must interface with and support the defense acquisition system (DAS) and planning, programming, budget, and execution (PPBE) processes at multiple points."

Capability, requirements, and affordability areas this JCDPR effort addressed include: requirements creep, improving capability metrics, prioritizing capabilities, promoting joint solutions that properly balance cost, schedule, and performance, improving affordability integration in the requirements development process, and developing incremental performance parameters and metrics.

J8 is also implementing the Capability Development Tracking Management (CDTM) system. CDTM is essentially a TurboTax-style fill-in-the-blank system for all DoD requirements documents. Its goal: move DoD's capability and requirements development from being "document-centric" to "data-centric." For the acquisition and resourcing communities, this should improve the speed of documenting and staffing capabilities and requirements as well as improve the consistency of the documents the JROC reviews. Additionally, J8 intends for CDTM to improve requirements traceability throughout the acquisition and resourcing processes, a persistent source of PM headaches and system cost increases.

How does all this impact affordability? In a word: stability. Stability in the form of requirements, funding, and schedule. It means doing the hard, up-front work correctly (and quickly) from the very beginning—starting with warfighter capability analysis. It also means using mechanisms later in the acquisition process such as Configuration Steering Boards (CSBs) and design reviews to fight costly "requirements creep" and schedule extensions. All of these collectively serve the affordability cause.

'The key is doing those engineering trades right at the beginning and then sticking with them.... You don't buy the car that you fantasize about. You first check how much money you have before you buy a car. And we need to start doing that.'

Question Two: "Where do we want to be?"

What has leadership said about this capability/requirements/affordability disconnect? Some of former Secretary Gates' views that relate capability and requirements to affordability goals:

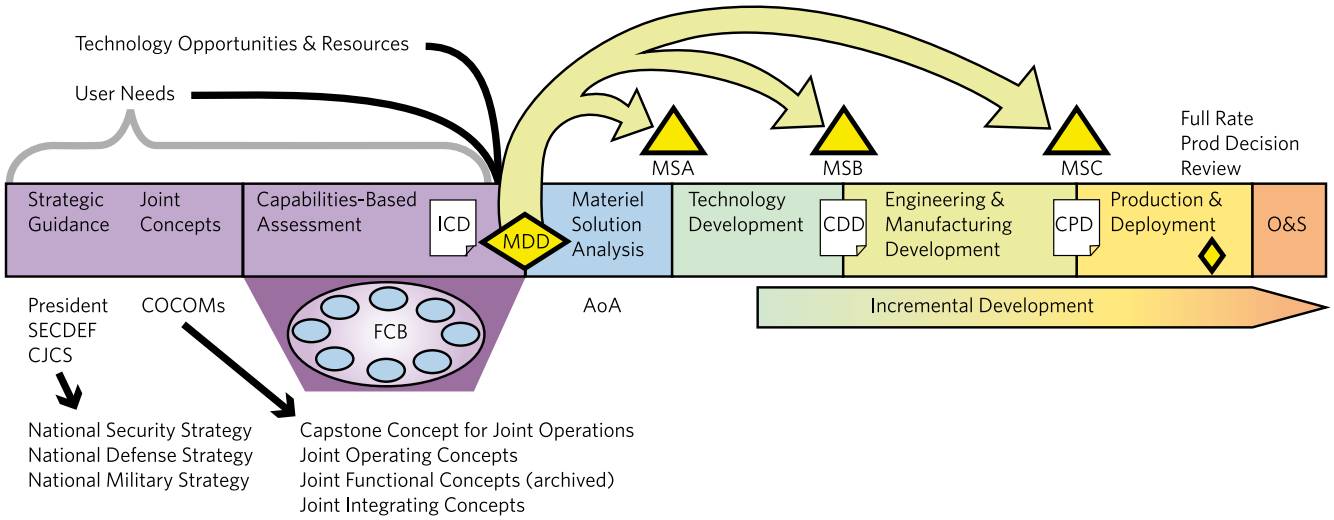
- "Affordability will be incorporated right at the beginning as a firm requirement for each new program..."
- "...we're trimming requirements without compromising critical capability."
- "Finally, while most people think of aircraft, ships, tanks and other weapons when they think of defense spending...DoD spends $220 billion on contracting for professional services, IT and facilities upkeep."

Dr. Carter's related thoughts:

- On being questioned about DoD's use of CSBs to increase requirements stability: "Yes, I support activities such as Configuration Steering Boards that prevent unnecessary changes to program requirements or system configuration that could have an adverse impact on program cost and/or schedule."
- "The key is doing those engineering trades right at the beginning and then sticking with them.... You don't buy the car that you fantasize about. You first check how much money you have before you buy a car. And we need to start doing that."
- "The alternative is broken programs, canceled programs, budgetary turbulence, the kind of unpredictability and uncertainty that are bad for industry; the erosion of taxpayers' confidence that they're getting value for their money; and of course, worst of all, lost warfighter capability.... It's now time for a DoD-wide behavioral shift."

Secretary Panetta's views in response to congressional questions:

Figure 2. Requirements and Acquisition



- "Secretary Gates has discussed with me his overall approach for the Comprehensive Review. It is my understanding that the process initiated focuses principally on driving program and budget decisions from choices about strategy and risks. Such a strategy-driven approach is essential to ensuring that we preserve a superb defense force to meet national security goals, even under fiscal pressure."
- "I will work with both DoD's civilian and military leaders to seek the right balance and I will not hesitate to provide my views on the potential consequences of proposed future changes in the DoD's budget."

Question Three: "What's the delta?"

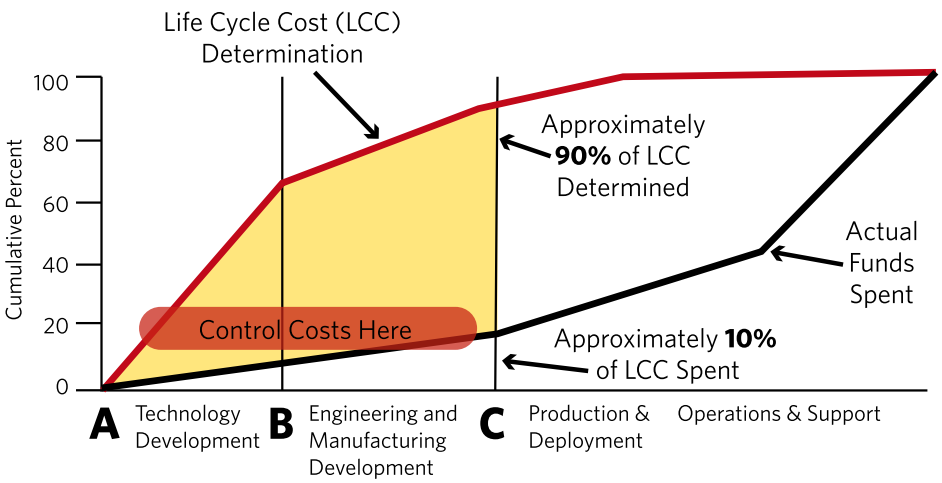
How do we get there? What might this behavioral shift demand? The maximum ability to impact a system's eventual affordability equation occurs at the very beginning of the effort to address a validated military capability gap. At this point in the process, DoD has spent little contractual money, prime contractors have not started the design work nor have subcontractors begun to bend metal. Nothing exists but the validated capability gap and possibly some government laboratory and industry Independent Research and Development (IR&D) findings. If done thoroughly (without sliding down that "paralysis by analysis" slope), these efforts can have a very positive impact on the price we ultimately pay for our systems. This pertains to new systems, replacement systems, or the resurrection of a cancelled Program of Record.

Furthermore, how does the operational requirements/affordability connection progress as the materiel solution evolves? Since capabilities analysis, operational requirements generation, and affordability are so interdependent, let's model this process chronologically from the very beginning, using the framework in Figure 2 and moving from left to right:

Pre-Material Development Decision (MDD)

At the far left, capability analyses are the foundation for operational and derived requirements that ultimately impacts warfighter battlefield performance. A DoD service or agency sees a problem—a possible capability gap that needs investigating. Using strategic guidance documents such as the Quadrennial Defense Review (QDR) and National Military Strategy (NMS) as well as joint conceptual documents such as the Joint Operating Concepts (JOC), Joint Capability Areas (JCAs), and existing archival data, the very first step is for the service or agency to initiate and fund a Capabilities-Based Assessment (CBA). If the CBA's findings and recommendations are rigor-

Figure 3. Life Cycle Affordability



ous and compelling enough to investigate a materiel solution, it's documented and staffed in the first of the requirements documents, the Initial Capabilities Document (ICD). This task is in the domain of the service requirements manager (RM) since there is no formal program office yet.

How do these early capability analyses impact affordability? Simply put, form follows function—system design and configuration follows technical and operational requirements established by early capability analyses. Identification of needed capabilities, gaps, and risks starts a causality chain that significantly impacts the system in a non-linear fashion as depicted in Figure 3.

For a typical DoD acquisition, by Milestone B the taxpayer has paid out less than 10 percent of life cycle cost funds yet the decisions coming from the capabilities analysis, operational and derived requirements development, and materiel acquisition processes have locked in over 60 percent of life cycle funds. At Milestone C, this figure rises to over 90 percent.

Where do our affordability problems begin? Highly variable capability analyses (ranging from nonexistent to multi-year studies) and operational requirements development can only increase a systems life cycle cost. Early capability analyses and operational and derived requirements development might appear too difficult, too costly, and too lengthy—and therefore tempting to rush through with minimum resources. However, players within the system must exercise discipline and do the proper analyses. Failure to do so negatively impacts not only solution selection but also creates the environment for developing inaccurate, overly-optimistic cost estimates. Unfortunately, given the time and money expended starting at MDD through retiring and disposing of the system, these inadequate capability analyses inevitably create a huge, unnecessary burden on the taxpayer—as evidenced by some recent, high-dollar Program of Record cancellations. The Army alone has canceled 22 major weapons programs since 1995, at an estimated cost of $32 billion for equipment that was never built or fielded.

Conversely, when done with discipline and the proper level of rigor, these analyses set up the program to achieve maximum affordability for a given capability. Additionally, significant savings can still occur during subsequent phases for any materiel acquisition. During the acquisition process, it's the PM's job to explain and defend the acquisition strategy while it's the RM's job to explain and defend warfighter operational requirements. However, ensuring the effort fulfills the warfighter's capability needs in the most cost-effective way is a cooperative effort. Let's examine these RM/PM interactions and taskings.

Post-MDD Technical Requirements Impact on Affordability

To support system affordability, the RM's job description evolves after the MDD into one of working within the acquisition and resourcing processes. Here, the RM helps ensure the various funding, technology development and maturity,

The Army alone has canceled 22 major weapons programs since 1995, at an estimated cost of $32 billion for equipment that was never built or fielded.

hardware, software, and support systems are focused on meeting warfighter capability needs. As the program evolves, the technical requirements become more refined and measurable—they evolve from capability gaps to KPPs to various contractual specifications and testing criteria. The RM's focus also evolves to keeping the focus on the warfighter to prevent the subtle but costly phenomenon of "requirements creep." Naturally, this includes supporting all Configuration Steering Boards (CSBs) to review all operational, derived, and technical requirements and significant technical configuration changes that have the potential to impact cost and schedule.

Material Solution Analysis (MSA)

During MSA, the RM serves affordability by helping the Analysis of Alternatives (AoA) Study Team understand the concepts of operation, as well as any Reliability, Availability, Maintainability Cost (RAM-C) goals for any proposed new capability. The RM then begins drafting a Capability Development Document (CDD) reflecting AoA results—the information in this draft CDD in turn helps develop the Request for Proposal (RFP). Systems engineering help is vital to the RM to ensure the KPPs and other operational performance parameters are technologically possible. If no program office yet exists, the RM works with the systems engineers at the acquisition command.

Technology Development (TD)

During TD, the RM impacts affordability by participating in program technical reviews, helping engineers understand operational and derived requirements and CONOPS, with the goal of writing better technical requirements and minimizing the number of KPPs and KSAs. Minimizing these significantly improves the chances for the program office and industry to deliver the solution on cost, on schedule, and with the right amount of performance—again, enhancing ultimate affordability. The RM also develops the final CDD after considering Preliminary Design Review (PDR) trades—in addition to participating in other program, technical, and decision reviews.

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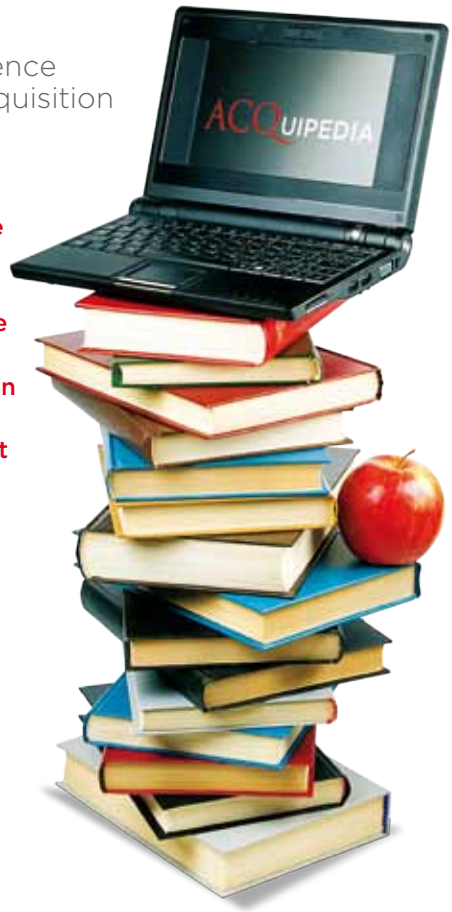

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Finally, RMs should be providing advice and assistance to the PM in development of the Acquisition Strategy, Acquisition Program Baseline (APB), Test and Evaluation Master Plan (TEMP), and the Life Cycle Sustainment Plan (LCSP)—all vital to determining ultimate system affordability.

Engineering and Manufacturing Development (EMD)

During EMD, the RM's impact on ultimate affordability lessens but is still vital to ensuring the program stays focused on the warfighter in the most efficient manner possible. RM duties include: ensuring all CDD performance attributes are "testable" by observing testing events; reviewing the CDD and the draft Capability Production Document (CPD) against these results, participating in T&E Working IPTs at the Pentagon level and T&E IPTs at the program office level: finalizing the CPD, revising the CONOPS prior to Milestone C, and helping the PM prepare for the Post-CDR Assessment, any resulting CSBs, and MS C.

Production and Deployment (PD)

During PD, RMs continue to assist the PM and their duties include continuation of all the duties listed above in EMD as well as assisting the PM with preparing for the Full-Rate Production Decision Review (FRPDR).

Operations and Support (O&S)

During O&S, the RMs should maintain contact with both the warfighter and the PM—this is after all, the most important phase for the warfighter. Here, the impact on affordability evolves again. RM O&S duties include: understanding that modifications and upgrades are not cheap and require program and budget lead time and funding justification, understanding that modifications and upgrades may be treated as new ACAT programs, and tracking threat, emerging technology, and life cycle cost reduction initiatives. They also obtain information on operations and support issues of the fielded system to support the next increment of an evolutionary acquisition strategy.

Summary

The foundation of system affordability begins during Pre-MDD capabilities analysis by carefully and thoughtfully analyzing warfighter capability needs. The affordability emphasis then evolves into immediate Post-MDD translation of validated capability gaps into usable operational, derived, and technical requirements, specifications, and metrics. Significant savings opportunities continue during later Post-MDD phases by cooperative diligence on the part of both RMs and PMs. This PM/RM team continuously reviews—and trades off if necessary—various requirements throughout the entire acquisition life cycle. Mutually supporting and accomplishing these tasks can go far to ensuring that early capability analyses, stable requirements development, and diligent materiel execution fully and competently support not only the needs of our warfighters in battle, but also the taxpayers who fund them.

The author can be reached at **jack.mohney@dau.mil.**

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Pay Me a Little Now or a Lot Later

Test and Evaluation Concepts to Assist in Managing Affordable Weapon Systems Programs

Mike Bohn

As the acquisition workforce embraces the challenge from senior defense officials to do more without more, all aspects of managing programs must be reviewed for efficiencies. In many development programs, the cost of testing to confirm performance is a significant expense.

Bohn *is a professor of acquisition management at DAU. He has 13 years of acquisition management experience and was the Operational Test Agency commander for the U.S. Marine Corps.*

A word of warning: While developmental testing is planned to be a "period of discovery," operational testing should be a "period of confirmation." Too often, operational testing has become a second discovery period.

Most important, the results from the test programs are used to determine if the product's performance will meet the warfighters' needs and are worth buying in production quantities. Well-thought-out test strategies developed in concert with other acquisition management strategies early in the program's life cycle help programs remain affordable in development and throughout their life cycle.

The Critical Role of Early Involvement

Early involvement by all stakeholders is key to program success. Getting the requirements right, translating them into contractual documents, and articulating an executable acquisition strategy are vital to developing affordable programs. Anything that can be upfront in the life of weapon system programs reduces uncertainty in the program's final outcome.

Early involvement of the test community in the process is no exception. In fact, due to the significant costs of development testing, the involvements of all members of the test and evaluation (T&E) community early in a program's life will result in a more stable and affordable test strategy. T&E specialists should be included in all phases of program development, in the following roles:

- Requirements development Integrated Product Teams (IPTs) should include T&E specialists to determine if the stated operational requirements are measureable, testable, and "make sense" when considered in an operational context.
- Contracting IPTs can use T&E experts in the development of Statements of Work (SOWs) and Request(s) for Proposals (RFPs) to ensure that T&E requirements included in these documents are complete, concise, and clear to industry and that industry has a fair opportunity to include these costs in their proposals to ensure they meet the warfighters' performance requirements.
- Source selection teams should include T&E persons on the technical review team to ensure that proposals include all necessary testing, that those costs associated with T&E have been properly identified and priced. More importantly, T&E specialists can determine if the proposed solutions can be reasonably evaluated in an operational environment to meet the needs of the warfighter or if additional testing should be added to the proposal costs to make up for a shortfall.

Early involvement of the T&E community is key to long-term program success in meeting cost, schedule, and performance goals. But only through the total integration of all aspects of T&E will testers be able support program managers in achieving affordable and executable programs for the warfighter and the taxpayer.

The Benefit of Integrated Testing

Simply stated, integrated testing is a collaborative effort by the entire T&E community to develop a strategy for test events with data that can be shared by all members of the test and program team for independent analysis, evaluation, and reporting. Efficient integrated testing should include all types of T&E: contractor developmental testing, government developmental testing, live-fire T&E, and operational testing. Both the director of operational T&E and the deputy assistant secretary of Defense for developmental test and evaluation strongly endorse integrated T&E to ensure program success.

A word of warning: While developmental testing is planned to be a "period of discovery," operational testing should be a "period of confirmation." Too often, operational testing has become a second discovery period. This occurs when there is inadequate time for developmental testing, a misunderstanding of operational concepts, or changes to the baseline configuration without full understanding of their impacts. If done properly, there are significant benefits to integrated testing:

- Integrated testing allows the sharing of data that all members of the test team can use to do their own analysis and evaluation. This reduces the number of actual test events by eliminating redundancy. Although integrated testing will never replace the statutory or prudent requirement to conduct separate and independent operational T&E, enabling operational testers to use verified data from integrated test events earlier in the program will provide clearer insight into a system's ability to complete initial operational test and evaluation (IOT&E) or operational evaluation (OPEVAL) and reduce the length of a system's operational test and the subsequent evaluation.
- Integrated testing and shared evaluation allows full visibility by the entire test and program team into the complete test program during the development phase and beyond. It ensures a smooth transition of primary responsibility for T&E throughout the life cycle, from contractor developmental testing to government developmental testers and, finally, to the operational testers.

- Integrated testing ensures that potential operational deficiencies are caught early in the development phase and corrected with enough time to verify that the fixes actually work, reducing the risk to the program's schedule and cost. Integrated testing conducted in a mission context with operational users participating will discover problems relating to operational effectiveness and suitability. These deficiencies can be identified, corrected, and verified long before the systems are formally evaluated during IOT&E or OPEVAL.

Integrated testing can enhance the affordability of a program by reducing the risk a program will experience cost growth late in development due to an unsuccessful operational test event that forces a retest, with the incumbent increase in cost and schedule. Integrating all test events will ensure a larger "bang for the buck," and help spend every T&E dollar effectively and efficiently. While many in the T&E community are accused of testing for the sake of testing, integrated testing forces the community to decide how much testing is truly required to make an informed recommendation and which test events are "nice to know." Anything that can be done to reduce the length of test events or the number of events while allowing the T&E community to gather enough data to make a complete, independent evaluation of a system's operational capabilities must be considered, to help program managers produce affordable weapon systems.

Ultimately, the true measure of success is whether a weapon system can be operated effectively by a trained warfighter, in the environment for which it is intended, against a representative enemy. Too often, traditional developmental testing processes only evaluate systems performance against specifications and leave out a mission context. While this may increase the likelihood of a successful test, losing an opportunity for early operational evaluation can create a significant residual program risk. Passing an operationally realistic test should be the new standard; units execute missions, not weapon systems. Integrated testing allows the T&E community and the warfighter earlier insight into operational performance, enhancing knowledge of the system's strengths and limitations.

A Cost-Effective Alternative to Testing

Integrated testing is a wonderful strategy to assist weapons programs in developing and executing affordable programs. Another alternative to improve affordability is a concept called design of experiments (DOE). DOE is an outstanding T&E concept that may allow a program to reduce the number of test events yet obtain the same insight into a weapon system's operational effectiveness and suitability.

DOE is a systematic method that uses quantitative, mission-oriented tools to predict how well a weapon system would perform within its operational envelope. Its objective is to uncover the most important factors to successful mission accomplishment. Testers can then systematically vary test factors to gather information using statistical measures of merit,

While many in the T&E community are accused of testing for the sake of testing, integrated testing forces the community to decide how much testing is truly required to make an informed recommendation and which test events are 'nice to know.'

called power and confidence. The importance of DOE is that it reduces the amount of test events required to gather the most important data with which to make sound acquisition decisions, while still ensuring test adequacy and confidence.

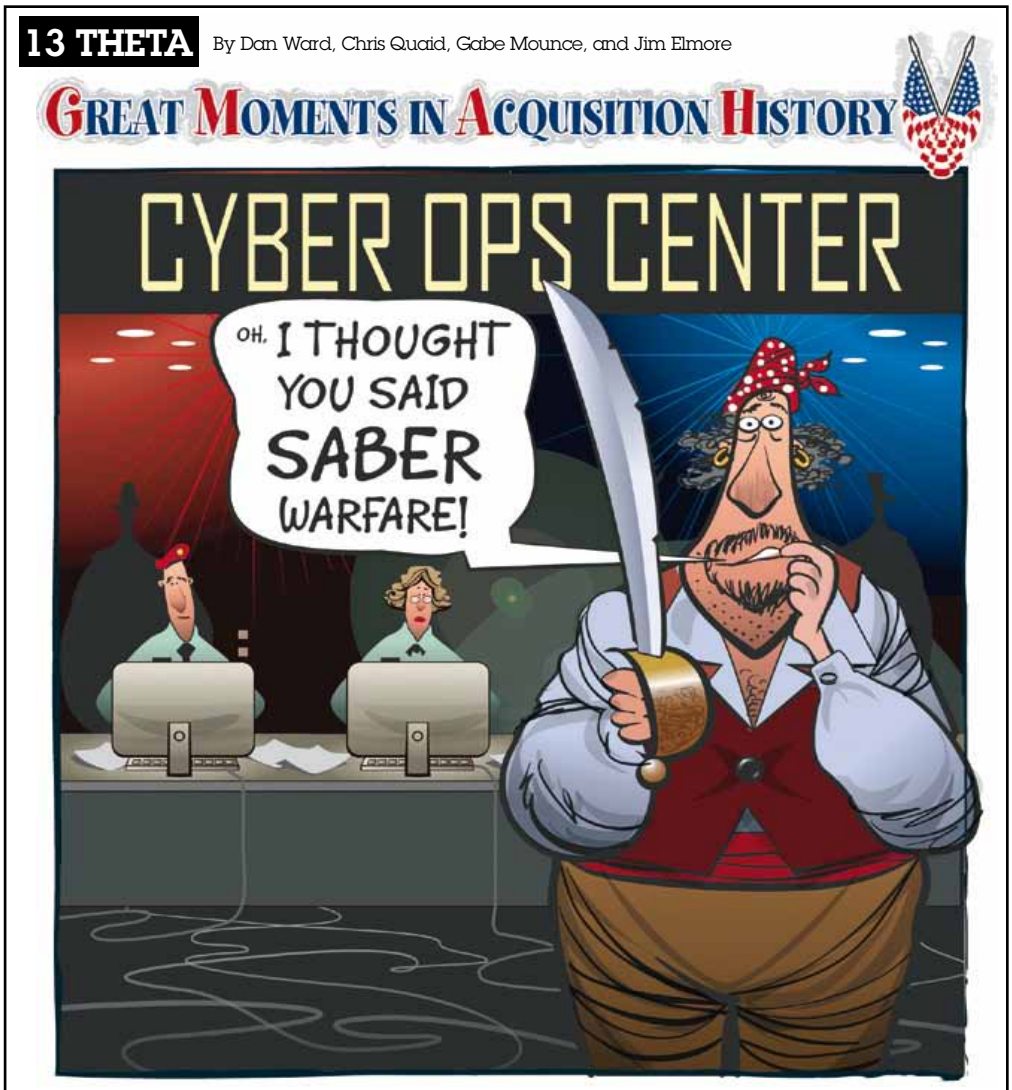
Reducing the amount of testing required should not only reduce cost and schedule but by collecting better scientific data earlier in the program's development phase it can foster making better decisions.

In a 2010 memorandum, "Guidance on the Use of Design of Experiments (DOE) in Operational Test and Evaluation," J. Michael Gilmore, Ph.D., director of operational test and evaluation, wrote: "The purpose is to ensure that the right type of data and enough of it are available to answer the questions of interest." Gilmore further states: "[DOE] is a structured process to identify the metrics, factors, and levels that most directly affect operational effectiveness and suitability and that should be reflected in detailed test plans."

DOE has been effectively used in the DoD operational test community since approximately 2008. It has been instrumental in saving a number weapons programs money and time, while obtaining the data the operational test community needs to evaluate each weapon system's operational effectiveness and suitability. During the quick reaction test of JDAM, the use of DOE saved approximately $3 million and 2 weeks of testing, compared with traditional testing. After a number of reliability failures, JASSM missiles were modified, and operational testing was required to validate the corrections. Traditional testing called for 21 missile shots. Using DOE, the number of required shots was reduced to 16,

and the amount of information obtained was greater for fewer resources. Using DOE to test the modifications to the JASSM saved the Air Force and American taxpayer nearly $7.2 million and reduced the test period by 60 days.

Despite this success, there is no single way to apply DOE in weapon system acquisition. There must be dialogue between all members of the test team, contractors, developmental testers, and operational testers to determine its best use throughout the test program. Additionally, discussion must take place to ascertain the proper variables, factors, and levels that will be used and how those things will be defined. Ultimately, DOE should be considered for use across the entire T&E continuum.



Bob discovers the importance of written communications.

A Well-Planned Test Program Can Be Affordable

Due to the costs of testing, T&E can have a significant positive impact on a weapon system's affordability. This may not translate into doing fewer tests, but creating a better test program can be a means of avoiding both upfront costs and the costs of redoing your mistakes. Early involvement by the T&E community in requirements can prevent ambiguous, unobtainable, or un-testable operational requirements. Early involvement in contract and program development will not provide the government with all the information needed to make decisions, but it can make sure the right test program is put on contract the first time. Poorly stated operational requirements and badly articulated contractual requirements waste time and money.

The same can be said for redundant and unnecessary repeated test events. Integrated testing allows the early discovery of deficiencies and seeks to maximize the use of valuable test resources, which will save the program office cost and schedule in the long term. Design of Experiments is a concept that, when methodically used within a program's test strategy, can reduce test assets and events, while still providing adequate data to allow the T&E community to independently assess progress or attainment of operational effectiveness and suitability.

The true success of a T&E program is an affordable, effective, and suitable weapon system in the hands of the warfighter as soon as possible. Weapon systems that fail to complete IOT&E or OPEVAL and are forced to go back through development and re-execute IOT&E not only become more expensive, but also fail to support the warfighter. The T&E community can be "value added" to any weapon systems program manager. The more emphasis program managers place on solid, integrated test and evaluation planning early in a program, the better chance that program will successfully complete IOT&E and get in the hands of our warfighters when they need it.

As the saying goes, "Pay me now, or pay me a *whole* lot more later!"

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Better Metrics for Better Communication as a Foundation for Better Program Buying Power

Dialogue Between Program Oversight and Program Execution Organizations

Brian Brodfuehrer

In his Better Buying Power memo, Under Secretary of Defense Dr. Ashton Carter recommended several actions, two of which were: "Reduce the number of OSD-level reviews to those necessary to uncover and respond to significant program issues" and "Reduce non-value-added overhead imposed on industry."

This intrigued me, because both actions were related to data I had recently gathered to facilitate a discussion dealing with the "program execution versus program oversight" nature of metrics, especially as related to cost estimates.

To support that discussion, I interviewed people with knowledge of and experience with the metrics good program managers use. They represented many years of acquisition experience in different product domains and stakeholder perspectives. For this article, I have quoted them anonymously.

Developing an effective set of metrics to be used by two organizations with differing interests establishes the context for this article's development, a shared emphasis on cost focuses that context a bit more.

Brodfuehrer *is a faculty member in DAU's PMT 401 course. He has over 30 years of acquisition experience working for both the government and industry.*

Metrics: The Good, the Bad, the Ugly

One thing that makes metrics ugly is that they are hard. It takes a lot of work to establish metrics properly, gather data on a regular basis, analyze the data, and decide how to act on it. Several experts commented on this: "If the value gained is less than the cost of gathering the metrics, don't do them." In other words, "You have to determine if the juice is worth the squeeze."

Metrics are also ugly because they can result in people being treated poorly. One senior acquisition program manager with experience in DoD and non-DoD systems said, "All federal acquisition is not high-trust. Honesty often results in axing heads."

An Air Force program manager working on a major joint aircraft program put it this way: "Metrics should measure processes, not people. The culture needs to be set [such] that when a metric goes south, management will seek to correct the processes (tools, training, and resources) and not take action against the people."

Another ugly aspect of program management metrics is dealing with numerous stakeholders and a rapidly growing IT environment. A large number of stakeholders represent distinct and varied interests, and each often desires different and more data. That desire is reinforced by the growth of information technologies that promise to gather and distribute larger amounts of data, faster, and to more people. Such growth sets high expectations for the art of the possible. Both trends push for more metrics, when fewer may be better. The ease of getting data can lure managers from focusing on the value proposition that the metrics are supposed to improve.

One source summed it up: "Knowledgeable stakeholders should pick a few insightful metrics and motivate the entire team to respond to them is the way to go rather than to gather a lot of data and not do anything with it."

Next, the "bad" of metrics: Program management is often about dealing with turbulence and bad turns of events. The program management environment, especially on

major programs, is one of responding to constant "I need data now!" fire drills. Frequently, data can portend bad news, and bad news does not get better with age. Not only are these drills time consuming, but they also take the PM's focus off program execution to attend to program explanation. A well understood, timely, shared, and consistent set of metrics can enable navigation in this bad environment.

In short, a good metrics program can soothe the savage oversight beast, meeting its need for information and tending to its fear of surprises. This is likely a harsh characterization of some oversight functions, but it represents a view from the execution side.

Another bad aspect of metrics has to do with the observer effect. Whether in physics or in the social sciences, the very act of taking a measurement can affect what is being measured. This can encourage bad behaviors leading to attitudes embodied in words like "spin." Care must be taken to avoid creating bad side behaviors when developing a metrics program.

"I can recall when I was a captain (Air Force), and I would be in the plant and spend long hours in the evening watching a software test or a qualification test and knowing exactly what happened. The next morning, I would sit in on the management team meeting and listen to their metrics for the event. I wondered if we were talking about the same event."

Finally, the good: A good side of metrics deals with empowering people by answering questions like "Where are we headed?" and "How are we meeting our value proposition?" When metrics show team members how they are achieving the program's objectives, they are more willing to set challenging goals and work hard to meet them. This is especially so when management or other partners, using the same metrics, provide the resources needed to meet the warfighter's needs while leaving more money in the taxpayers' pockets. "Think of it this way: Metrics don't only measure behavior; they drive behavior," said one program manager.

Another good use of metrics is to enable the use of relevant and timely data instead of conjecture to make decisions. Good metrics encourage the dual, technical-social nature of program management; their data is solid and they motivate productive human behavior. One more good side of metrics is that much work has been done to develop a large number of programmatic metrics and to organize them in a way that they can be used effectively across the enterprise. This article assumes the reader is aware of methods such as probability of program success (PoPs) in use across the DoD enterprise.

Metrics and Cost Growth: Differing Estimates, Errors, Decisions and Execution

One thing that can shape the discussion between program execution and program oversight organizations is when they have differing cost estimates. These represent both challenges and opportunities.

A challenge is how to determine which estimate is "right" and thus which number to use for budget purposes. Another is how to work the people side of coming to an agreement.

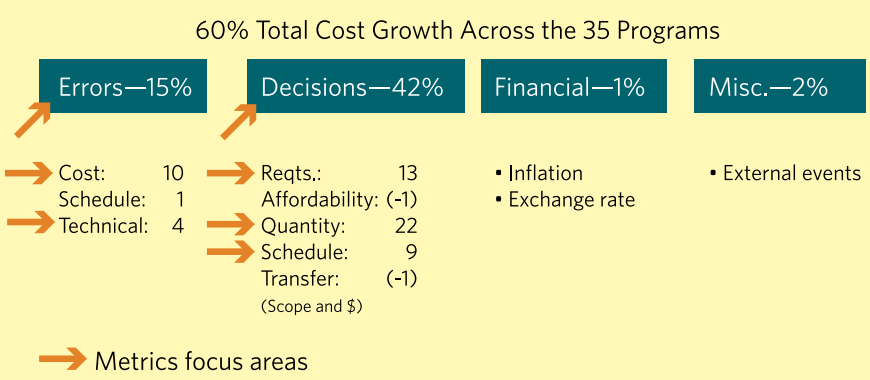
Opportunities exist, too. Identify the differences between the estimates, and look at the assumptions that drive the differences. These differences represent prime areas where metrics could be shared between organizations. Assumptions could be tracked over time to determine which ones materialized. Where are the unknowns in the two estimates and how will they be clarified? Unknowns drive cost. Differences in estimates represent areas where more dialogue may be needed to better have a common understanding of the program. Where estimates are the same there are opportunities too. The estimate could be right on, or perhaps it is too conservative, and cost could be reduced.

Working through the process of using the data from differing cost estimates to select a mutually agreed to set of metrics can: improve long-term communication, enable better joint decision making and reduce the oversight burden—all of which will have a positive impact on program affordability.

Errors and Decisions

In 2008, a RAND Corp. study showed that total cost growth for 35 major defense acquisition programs was dominated first by decisions made after the baseline estimate and second by errors in the baseline estimate. Decisions accounted for more than two thirds of the growth and errors for a quarter of the growth. Thus decisions and errors, in that order of priority, could be a useful way to further focus the dialog between the organizations. (See Figure 1.)

Figure 1. RAND Study: Sources of Cost Growth



Let's take errors first. One area impacting errors is proper estimation of the amount of design work versus true commercial-off-the-shelf (COTS) work in the program. Work requiring some type of design such as modified COTS differs from non-developmental item, re-use, or heritage. Metrics tracking these areas can be used to show trends as the program matures against the original estimates.

"Metrics should measure processes, not people. The culture needs to be set [such] that when a metric goes south, management will seek to correct the processes (tools, training, and resources) and not take action against the people."

Said one PM: "Program managers need to know how much of their program is or is planned to be re-use. This goes for both hardware and software. Will it really be COTS, or will it be modified COTS? For a program that is using existing hardware, do you know how many obsolete parts are in the boxes? How about diminishing manufacturing suppliers, how many of these will your planned effort have to deal with? Tracking and understanding these types of metrics can change your whole management approach. You may have signed up for a production program and find out that in reality you have one very much in development."

This concept can also be used in a related way for software. "Track how many software modules need to be designed. If the number is increasing then you know you have a growth problem. It could be due to adding more to the program or to not understanding the original task."

Another cost growth driver from errors in estimates are the technical issues the program faces, or, its technology maturity. Here, technology readiness levels (TRLs), when properly applied, are a helpful measure. Progress in the development of the technology along the TRL continuum, as compared with what was planned, can be tracked as a metric.

Known Unknowns

A third element affecting cost growth is capturing and dealing with the numbers of unknowns programs typically have early in their life cycle. A list of unknowns and decisions that need to be made across the acquisition spectrum (cost, schedule, performance, risk, stakeholders) can be made and progress tracked to completing actions necessary to bring clarity to the unknowns. Dealing with these unknowns will affect cost growth due both to errors and decisions.

Next, let's deal with the decision aspect. The RAND study pointed out that decisions made by the government after the original estimate to change quantities, add requirements or change the schedule significantly impact cost growth. Metrics after Milestone B will be necessary to ensure that decisions made are not causing requirements creep.

Examples of these might be: how many inter-agency memorandums of agreement are required and how many are completed? How many interface control drawings (ICDs) are required and how many completed? How many unknowns, such as "to be determineds" (TBDs) are in the ICD or specification documents? And what is the plan to burn them off?

"Most programs track the number of Class I changes. But what about the Class II changes? You need to have a way to ensure that a series of Class II changes won't add up to bite you."

"How are you identifying your unknowns and trying to put certainty into that uncertainty? What are the key decisions and when do they need to be made to keep the acquisition on track?"

"When doing software testing, you can't test every possible state. Also some coders leave paths behind that are terminated and not to be used. How many of the total population of possible states you could get into have you tested?"

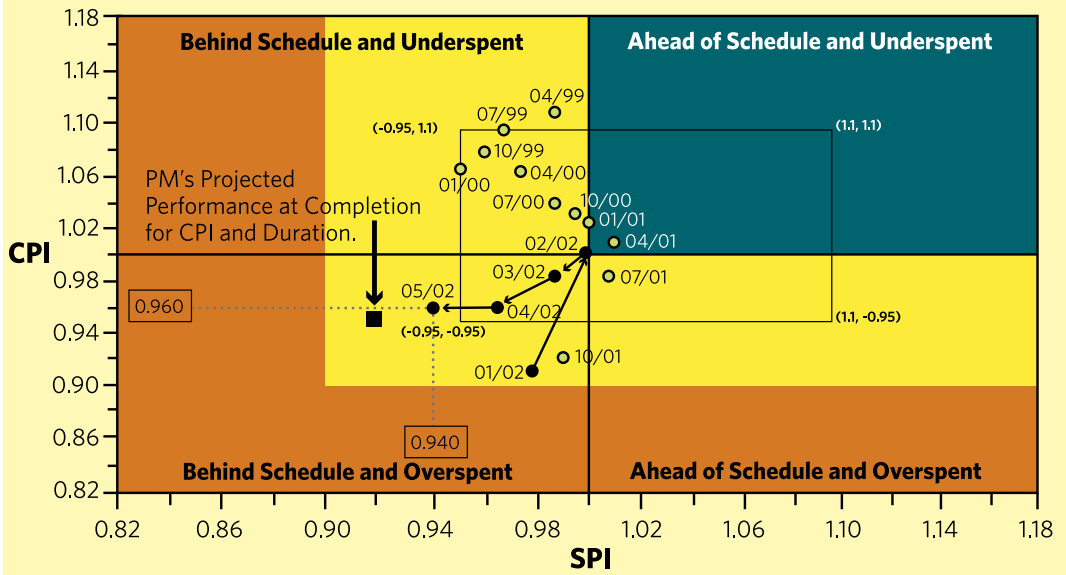
"How are you managing risk? The risk management program in itself is a series of metrics and success in controlling cost growth, especially in the technical maturity area, is directly related to managing the risks you have."

Using metrics to bound errors from the original estimates and to monitor and control decisions made after program start can improve program affordability.

Execution-Based Metrics

The ultimate goal of any set of metrics is the ability to forecast the future with enough lead time for actions which can effectively improve the predicted outcome. A challenge with metrics is that they are only as good as the assumptions made when they were created. Frequently as time passes, while the metrics collected are dutifully plotted and tracked, the assumptions behind them are forgotten rendering the current PM to only guess at their real meaning and usefulness.

Figure 2. Execution—Contract Earned Value Metrics



"EVM is a great tool, but the assumptions are important. How is the contractor measuring progress on a work package? Does he take 75 percent just for opening the package? That is a problem."

"One of the best ways I have seen to use EV data is to plot out SPI and CPI for each month and look for trends. I would draw a box around an area of small change and within that box consider the variations normal program jitter. What I looked for was trends, it worked great. And it was also useful to look at the program after a re-baselining; [seeing] the same trend means the original problem was not fixed." (See Figure 2.)

"A complete integrated master schedule (IMS) is important. I once asked to see one of my new program manager's IMS and what they showed me just represented the contracted part of the effort; it did not include other partners' or the government's part. It is not an IMS without the whole picture."

"A good IMS is critical; everything else depends on that. The earned value, everything. How many orphans are in the schedule? If a task has no parent, then why is it part of the plan? If it has no children, then how big is it, and how much work is required? Those represent unknowns."

A final challenge with execution metrics is that frequently the acceptability of the message is more dependent on the messenger than the data provided. Several of the managers interviewed said they would watch for this constantly, because a skilled messenger can make even sour milk taste sweet.

"I liked to pull a cost account manager's (CAM) name from a hat and ask that person to brief their status rather than rely only on the company to choose the CAMs who present at meetings."

"Industry and the government should use the same set of books. There should be almost real time access to data by the government after it is posted by the contractor."

Good execution-focused metrics enable better decisions and better decisions improve program affordability.

Summary

Carter's memo challenges the acquisition community to vigorously find ways to improve the buying power of the Department so that it can better face a challenging threat in a climate of constrained budgets. This will require, once again, a change in culture or mind set on the part of the acquisition community. The last quote, about the power of culture to navigate conventional acquisition systems to deliver capability to warfighters, comes from a program manager who worked acquisition for the Special Operations Forces (SOF) community:

> There is a myth that the Special Operations community executes acquisition through unlimited funding, higher priority, dodging the rules. The reality is that yes, there are benefits to having a smaller community and a more direct line to decision and budget authorities, but these benefits are offset by more demanding operational environments and higher customer expectations. The difference is the way SOF gets it done. They have a 'can do, must do' attitude that enables them to navigate through conventional acquisition systems to deliver capability.

Metrics drive behavior, and taking the time to establish those better metrics can create the attitude and communication necessary to satisfy the varied interests of stakeholders and improve the buying power the whole acquisition community in years ahead.

Finally, productive dialogue between execution and oversight organizations will be central to the way forward and hopefully this article has provided ideas, based on actual practice, to guide that dialogue.

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Tech Data, Please

David L. Gallop

Tech Data Rights, Competition, and Affordable Sustainment

The operations and sustainment (O&S) phase costs for a weapon system often exceed 50 percent of the system's life cycle cost. This makes O&S costs a prime target for affordability initiatives. By introducing competition into the procurement of logistics support, spares, and upgrades to systems, experts believe we can achieve 15-percent cost reduction, compared with a sole-source procurement of the same products and services. For example, the Army expects to achieve O&S cost savings by using contractor-developed tech data in a full and open competition of M4 carbine spare parts. Government control of tech data and computer software (usually through assertion of the appropriate license rights) enables competition in the O&S phase but requires planning in the pre-solicitation phase of the program.

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The GAO found that the lack of technical data rights has limited program managers' (PMs') flexibility to achieve cost savings in the O&S phase through competition. Unless PMs assess the benefits of and secure the rights to tech data early in the weapon system acquisition process, when they have the greatest leverage to negotiate, they may face difficulty obtaining the tech data to reduce O&S costs through competition or depot maintenance.

When the Air Force purchased cowlings for the Airborne Warning and Control System (AWACS) aircraft, it did so on a noncompetitive, sole-source basis. The Defense Contract Management Agency recommended that the program office compete the cowlings, because the original equipment manufacturer's proposed price was not fair and reasonable and because another potential source for the part was available. Despite the recommendation, however, the Air Force said it "lacked the technical data to compete the purchase."

Since government tech data rights have costs and may have limitations, the program manager must have a tech data plan as part of the acquisition strategy that considers the benefits (affordability in the O&S phase), as well as the costs and limitations. The PM can make technical decisions that improve the utility of tech data obtained early in the life cycle, rather than pay a premium later in the life cycle.

Technical Planning Considerations

The Long Endurance Multi-Intelligence Vehicle (LEMV) program aggressively pursued tech data rights under their other transactions authority (OTA). The government obtained special license rights that equate to Government Purpose Rights for all deliverable tech data and computer software, to include contractor-developed items prior to the OTA. This provides the PM with a strong basis for competition when the program transitions to a Federal Acquisition Regulation-based contract at Milestone B and beyond. This is an excellent example of managing the technical data as part of a tech data strategy to improve competition and affordability later in the life cycle.

During pre-solicitation, PMs can take two technical approaches to the system that can maximize the utility of tech data to achieve O&S affordability through competition. **Have an open system architecture (OSA)** and **design for modularity**. An OSA uses interface specifications maintained by open, public consensus. Modularity is the degree to which a weapon system is made up of relatively independent but interlocking components. If the goal is to maximize the competitive environment in O&S, the perfect system would have no proprietary interfaces, 100-percent modularity and all of the modules would be commodities (quality is not dependent on the manufacturer). Since this "perfect system" is uncommon, PMs need to focus their tech data rights assessments on components that will provide the greatest benefit from competition later in the life cycle.

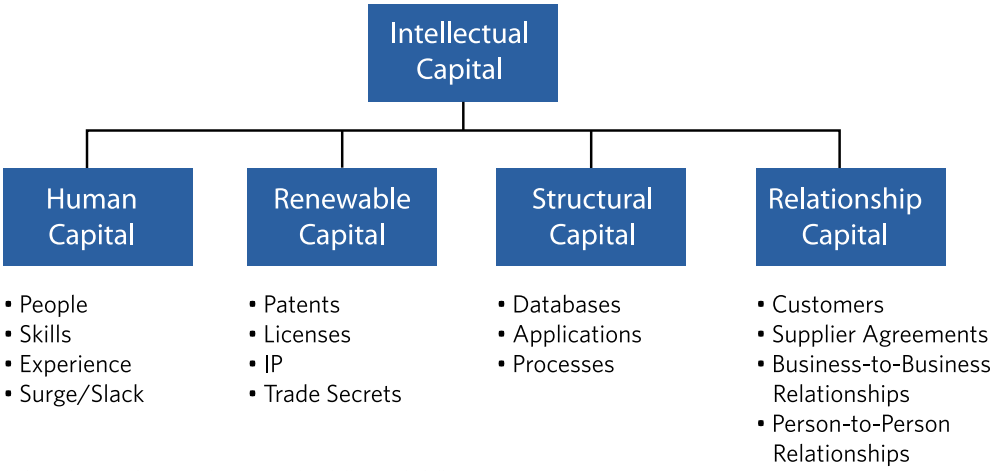
OSA and modularity allow the program manager to focus the tech data rights assertion decision on the nonstandard interfaces and the cost-driver components. They facilitate the identification of tech data required to sustain, integrate, and meet user requirements. The program manager can then use economic modeling to weigh the investment of asserting tech data rights against the potential savings through competition. This focused approach to asserting tech data supports the system's business case analysis. It also communicates the government's intentions for the tech data to industry more effectively than a broad system approach—such as unlimited rights to all data.

Government control of tech data is a powerful tool for competition in the costly O&S phase of a program. Its utility is amplified if the technology planning considers OSA and modularity. OSA and modularity allows the program manager to be precise in the tech data rights the government asserts. However, government control of tech data does not guarantee competition or capability that meets requirements. Government control may not be appropriate based on the tech data's dependency on the contractor's intellectual capital (IC).

Limitations of Tech Data for Competition

Tech data is intellectual property (IP). IP is not the same as IC. When you place a company on contract for product development, you are tapping into that company's (or team of companies') intellectual capital. Tech data are an important part of the IC equation. However, it is only one part. All of the components of intellectual capital are interrelated and necessary to deliver, maintain, sustain, adapt, and improve capability. When

Figure 1. Intellectual Capital Components



Adapted from "Show Me the Money" by Phillips and Phillips

you remove the tech data from the other components of the company's intellectual capital, the tech data may have reduced value and impact. There are four components of intellectual capital: human capital, renewable capital, structural capital, and relationship capital.

Human capital, also known as individual capital, is the contractor's collection of personnel expertise and experience. Without that expertise and experience, there is no tech data. Companies transform individual experiences and expertise into new, shared knowledge. Companies recruit and retain talent critical to profitability and growth. They align expertise against work on-hand to maximize direct charges and minimize indirect costs. In fact, a great deal of management focus is on maintaining the right bench of talent and organizing that talent into project teams and adjusting the bench over the entire product life cycle.

Compared to the government, companies have tremendous agility to surge and slack their workforce for cost effectiveness. They match the work required at the point of the product life cycle with the workforce experience and expertise. The successful application of tech data in the program's acquisition strategy will need to consider the dependency of the tech data on the contractor's human capital. If the creation of the tech data required a skill set or experience unique to the contractor, the tech data may not be a good candidate for government control with the intent to compete the work associated with the tech data in O&S. The program management office may not have the skills to interpret the tech data to adequately describe the needs in a solicitation. Potential bidders may not exist or be able to deliver the capability.

Renewable capital is the contractor's intellectual properties. These include patents, licenses, and technical data. Renewable capital leads to marketable innovations—products, services, and technology. It is the connection between patents, licenses, and technical data that makes the transfer of tech data outside the company a risk to the company's competitiveness. Naturally, companies will defend and protect the tech data. There may be dependencies between the tech data under government control (through the assertion of licensing rights) and company patents and trade secrets. Not all potential bidders later in the life cycle can replicate those patents and trade secrets.

Structural capital is the contractor's work processes. The output of these work processes is documentation. The contractor may provide the government with tech data in a form that is incomplete, ambiguous, or of limited utility because of dependencies between the tech data and the elements of structural capital. For example, the contractor may provide mechanical drawings as tech data in Adobe Acrobat format. These drawings may need to be in SolidWorks format to be useful to future bidders. The program manager developing an acquisition strategy must consider these dependencies by requiring the tech data in a useful format, have the appropriate applications and databases, and plan to have access to people with the knowledge and skills to use that data in future solicitations.

If the creation of the tech data required a skill set or experience unique to the contractor, the tech data may not be a good candidate for control with the intent to compete the work associated with the tech data in O&S.

The final component of intellectual capital is relationship capital. Relationship capital is the contractor's network of resources—their contacts and supplier relationships. The government may not fully appreciate this component of intellectual capital because it is often running in the background of the contractual relationship. Relationship capital includes access to information such as changes in raw materials and parts availability, alternate sources of supply, etc. It also includes the contractor's unique network of influence with suppliers, program advocates, and other government customers. Those relationships can often be replaced but not always duplicated.

The program manager must consider the limitations of tech data at each milestone and adjust the tech data plan accordingly. It requires a great deal of forecasting to improve the likelihood that the tech data the government acquires will be available, useable in a solicitation, and that real competition will exist in the future.

Conclusion

Government control of tech data and software, combined with OSA and modularity, can reduce O&S costs through competition. The program manager must consider the value of tech data rights in relation to OSA and modularity during technical planning. In most cases, the program manager will need to be selective in the assertion of tech data rights. At subsequent decision points, the program manager must consider the dependencies between the tech data and the contractor's intellectual capital. This may require adjustments in the skills within the PMO over time and a constant assessment of the competitive environment to maximize efficiency and achieve cost reductions through competition.

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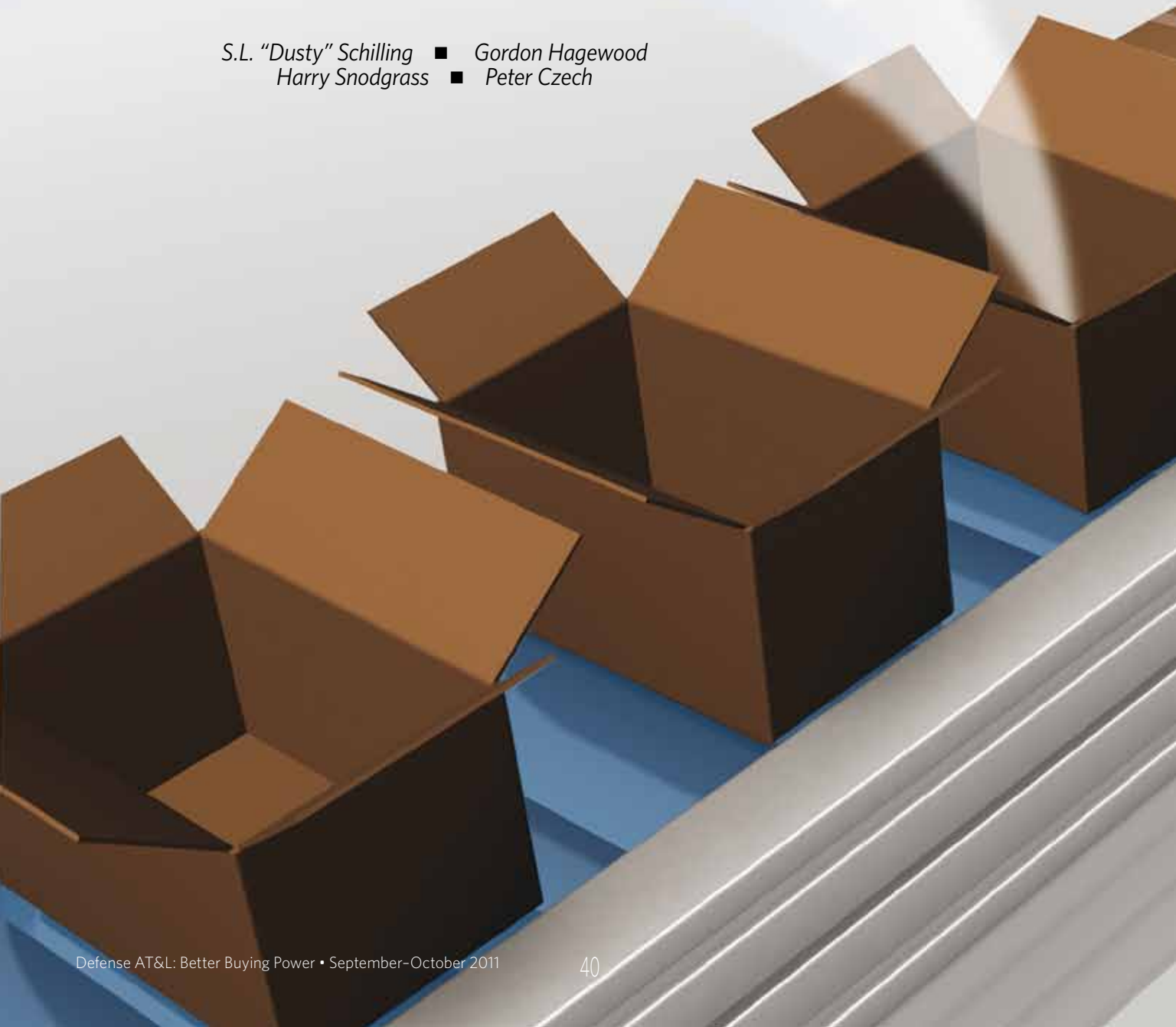
Manufacturing Affordability

S.L. "Dusty" Schilling ■ Gordon Hagewood
Harry Snodgrass ■ Peter Czech



Recent statutory and policy changes have stressed the need for program affordability and identified areas where it might be best achieved. This renewed focus is based on anticipated challenges to future DoD budgets—as we decrease our operational tempo and as we face the largest deficits and national debt in our history. Within the traditional trade space of affordable cost, technical perfor-

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mance, and timely delivery, affordability has been elevated to at least a quasi if not de facto key performance parameter.

Every major program has significant touch labor opportunities to leverage and part of the producibility plan needs to be a formal system for review and application of lessons learned.

Manufacturing affordability is a significant factor in achieving overall program affordability. That said, affordability in manufacturing is not a task that can be mandated. Directing that preliminary design reviews be accomplished prior to Milestone B falls into the "mandated" category. It follows a simple "if/then/else" logic of disciplined completion criteria. In contrast, affordability in manufacturing is an outcome of how programs are managed.

Effective planning early in and throughout program development is critical to enabling manufacturing affordability. There is no silver bullet and no magic to ensuring manufacturing affordability. To succeed, we must get back to the basics.

Our research identifies at least four essential elements of controlling manufacturing costs:

1) Broad-based engineering design trades that consider production line planning and producibility early in program life cycle

Achieving affordability for DoD weapon systems and products requires a focused effort on producibility during the initial phase of weapon system design.

So what is this producibility focus?

Producibility requires a coordinated effort by the systems/design engineering team and the manufacturing/industrial engineering team. Functional hardware designs that can be consistently replicated with the desired quality, lead time, and cost objectives are the goal, and, if well executed, the result. As trades are considered for capability, schedule, and design costs, their impact on manufacturing as part of an overall producibility program must be considered: Will my suggested change in performance drive the need for critical technologies in my production line that do not currently exist? Can a schedule change subsequently impact my schedule for prototyping my initial production line? If I lean out cost from my preliminary design effort, will that be at the expense of my overall producibility plan or product quality?

Design should optimize the ease and economy of fabrication, assembly, inspection, test and acceptance—the latter two representing some measure of quality. Quality is the ability to produce this product without non-conformances or issues that cause the part to fail inspection. Good design can dramatically reduce the need for inspection. Good design also considers reliability and maintainability of the product. These considerations complement the engineering and manufacturing planning that includes the selection of materials, tooling, facilities, capital equipment, test equipment, methods, processes, and personnel to make the product.

We learn through experience. And typically, some experience consists of unexpected lessons. "Gee, this stove is hot" may be an unexpected lesson for the toddler but should not be so for the adult. All production programs learn important producibility lessons during the actual manufacturing process. A more proactive approach would incorporate producibility best practices much earlier in the design process. If your focus as a program manager is only on how well you design the product to meet performance, and not how efficiently it can be manufactured, then do not be surprised when you are overcome by scrap, rework, and costly redesign!

So who is responsible for producibility? Every PM should be able to answer this question about his or her program. Perhaps you have heard the saying: "In the commercial world, nobody gets paid until something gets made." That said, defense industry design engineers get paid long before and after anything gets made. That does not mean they don't continue to participate in the manufacturing affordability process.

There is design engineering, and there is manufacturing engineering; rarely can one individual do it all. If you don't have significant participation from the manufacturing side of the business in program design efforts from day 1 of Engineering and Manufacturing Development, you should be seriously worried. A program that includes the following types of considerations can execute a producibility program with significant cost savings when compared with traditional, less structured approaches.

2) Controlling physical configurations

Once we start production, a key element to controlling manufacturing costs is reducing configuration changes. Controlling change limits unexpected alterations to material buys, to production line processes and contributes to constraining cost growth. Changing a line on a design drawing while early in the paper phase is low cost. Making that same change later may still be a great idea, but the implications will be costly. These changes may affect many things, including significant

documentation change costs; redesign of sub-systems and components, and even actual production line equipment such as tooling (jigs, dies, and fixtures), machine setup, work instructions, etc.

But wait! We want learning curve improvements included in our production runs, right? Learning curve improvements are generally linked to touch labor efficiencies gained through repetition. These gains really do demonstrate the meaning of "practice makes perfect if you practice perfectly." Every major program has significant touch labor opportunities to leverage and part of the producibility plan needs to be a formal system for review and application of lessons learned. Yes, we do want some change, if that change results in producibility improvements and net cost savings.

Consider that cell phone in your pocket. During its production run, an incremental design update would be a rare event. Further, production would not stop "just to tweak the system for a little more performance." Large production lots run to completion, and only then are significantly new variants introduced. Given the nature of DoD products, we may feel the need to introduce technical performance changes during production, but in terms of controlling manufacturing cost, you are far better off getting the product design frozen up front.

Remember, EMD stands for engineering and manufacturing development. Knowing what is "good enough" in the design engineering phase can help us develop the required producibility improvements during the manufacturing phase. If no other point is apparent by now, it should be that there are myriad variables to consider from initial design through full-rate production. Establishing the right balance takes a skillful PM with a disciplined internal stakeholder management and communication plan that makes all areas of potential trade clear and mutually understood. A disciplined battle rhythm that executes these plans needs to be established as part of the technology development phase and tailored as the program matures.

3) Stabilizing lot and total quantity buys

For decades, the defense community has recognized the negative impacts of production quantity instability. All of us know that uncertainty in annual lot sizes and reductions in the total quantity buy lead to per unit prices increases. But how many of us really understand how to talk about the specifics?

Economic order quantity (EOQ), economical production rate (EPR) and minimum sustaining rate (MSR) are familiar terms that sound obvious but are surprisingly difficult to pin down and use effectively in communication. The first challenge is that these terms are specific not only to a product, but also to a particular producer's specific situation. Calculations for one supplier may not be same as for another. How many production lines or facilities do we require? How many shifts will the vendor run? Is the order large enough to keep one facility operating all year? Will there be a break in production between annual buys? All these factors and more go into the determination of EOQ, EPR, and MSR.

Be aware that EPR and EOQ are not really the same thing. In DoD, we often use EOQ to refer to, well, what it sounds like it ought to mean—the most economical rate for buying end-item deliverables to the government. If you as a PM are talking about EOQ when discussing what budget levels to fund to and what size lot buys to make, you are probably using EOQ in the above sense.

However, in industry, EOQ (sometimes called the Wilson EOQ) is commonly used when determining inventory stock buys, because that EOQ calculation factors in things like costs of holding inventory and order placement costs. Within DoD, that specific use of the term EOQ calculation is associated with advanced procurement material, not with final end-item deliverables.

Regarding EPR: Please note that that technically, the EPR calculation is defined in the DoD Financial Management Regulations specifically referring to one shift, 8 hours per day for 5 days per week, which may in fact not be the most economical lot-size order.

The bottom line is that you, the PM, need to understand how to communicate effectively about quantity instability impacts, to recognize that you will be dependent on industry providing production rate and minimum sustaining rate estimates, and that your ability to assess their accuracy will be limited.

Stabilized production rates would significantly aid achievement of manufacturing affordability across DoD. We all know that the service budget allocations drive the production numbers, and yes, we know that programs report these EPR/MSR numbers yearly on their P-form budget submissions. In addition, we understand that executing above a specific economic rate may make some people see your program as a funding source target. However, a new aspect to the funding allocation decision process might be reviewing how efficiently our entire DoD portfolio is performing. Perhaps we should expect to see the acquisition community:

- Focus in Defense Acquisition Board reviews on production rate funding commitments.
- Issue Milestone B and C acquisition decision memorandum direction for programs to achieve specific production rates.
- Publish overall assessments of how many acquisition category 1D and 1C programs are executing above economic production rate.

If this does in fact become a hot topic for senior management, it may be worth the while of individual program managers to understand just how confident they are in the development of and articulation of their program's EPR and MSR numbers.

4) Fitting manufacturing needs into contractor's strategic business plan

Efficient and affordable production depends on the industrial base supporting the specific type of manufacturing you need. However, significant change is on the horizon for U.S. industry. We in government may read about the many news reports detailing the emergence of China and other countries as sources of both manufactured goods and raw materials, but for industry, correctly positioning themselves in the competitive marketplace is critical.

Although stability in product design and quantity aid greatly in controlling manufacturing costs, the most fundamental truth is that early and persistent planning during design is critical to enabling manufacturing affordability during production.

One challenge we government program managers face as we approach acquisition programs is how to fit our manufacturing needs into our contractor's strategic business plans. Why is that important to me?

Most companies have long-term strategies in their business plans that guide them to which types of manufacturing programs they will embrace. Companies perform detailed analysis of the capital investment that is designed to decrease manufacturing unit costs. Companies conduct a thorough scrutiny of opportunities through the lens of cash flow, risk, profitability, labor requirements, and fit with corporate strategy. Experience, supported by data, demonstrates that manufacturing risk increases as the business moves from adding a few more units to the production process to starting an entirely new production line.

As a government PM, you might not be required to investigate this information. But as the contractor, when risk increases, so does the price. As a government PM, you need to investigate how our designs will affect the potential reuse of existing facilities, and the cost implications of the impacts associated with the risks that result from your decisions.

So what should a government PM be looking for in the industrial sector? Which companies look like a good fit strategically?

- How similar is your new program with the products the supplier is currently manufacturing?
- What are the current margins for the products being manufactured?
- What strategic manufacturing process will the supplier be able to capitalize on for future business? (e.g., a new robotic welding process)
- What advantages do you see for the supply base?
- What is the current state of manufacturing for your sector? What advantages or disadvantages does this situation bring to your project?

Knowing the suppliers' long-term strategy will help in making your program's manufacturing planning more viable.

Summary

Manufacturers with proven producibility programs have experienced 30 percent reductions in product development cost and time. These savings come from reductions of 50 percent in design changes, and most importantly 70 percent reductions in engineering changes after a parts initial release for production. These result in reductions in design labor costs and production rework.

Reductions of 30-50 percent in design labor costs, as represented by decreases in design labor time, are achievable. Likewise, producibility programs can reduce rework by as much as 80 percent. Given projections of the DoD budget, these are the kind of numbers we need to make our next generation weapon systems affordable.

Affordability in manufacturing is not one specific quantifiable task but, rather, an outcome of good program management. There is no silver bullet and no magic to production affordability. Although stability in product design and quantity aid greatly in controlling manufacturing costs, the fundamental truth is that early and persistent planning during design is critical to enabling manufacturing affordability during production. Internal stakeholder and communications plans, executed with a predictable battle rhythm, can help ensure success. Integral to these plans is the cross-functional visibility and common understanding of the factors that compete for attention from initial design to full-rate production. The authors agree that renewed emphasis on affordability in general, and manufacturing affordability in particular, are important initiatives for the Department—especially in view of anticipated fiscal challenges.

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Sound Cost Estimating:

A Pre-Requisite to Ascertaining Affordability of DoD Programs

Mark Husband, Ph.D.

The guidance for achieving better buying power set forth in Dr. Carter's Sept. 14, 2010, memo requires action by every member of the acquisition community. This article considers just two of the many processes that are critical for program success: conducting a sound program life cycle cost estimate and establishing a program's budget. These two processes are interlinked in that the best available cost estimate should be used to determine the program budget, not only at major acquisition milestones, but also annually during the budgeting cycle. Interlinking of these processes is meant to ensure that the resources devoted to large programs are sufficient to complete them successfully, based on a comprehensive oversight process that includes scrutiny at least at major milestones as well as annual re-evaluations as part of DoD's budgeting process.

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Yet despite DoD's extensive oversight process and the best efforts of its workforce, the Department's acquisition programs are increasingly plagued by worsening cost and schedule growth and failure to deliver promised performance. While conducting sound estimates and appropriately establishing program budgets cannot ensure successful outcomes, they are two key processes that must be done right if a program is to have any chance of success.

Sound Cost Estimates

Conducting a sound cost estimate is a very difficult task. "It's tough to make predictions, especially about the future," has been variously attributed to Niels Bohr, Mark Twain and, of course, Yogi Berra. In his best-selling book *The Black Swan*, Nassim Taleb addresses humanity's horrible record of predicting the future, and particularly bemoans the fact that, because of our facility in inventing stories that convince us we understand the past, we unaccountably continue to believe we can predict the future well. He attributes our poor record in predicting to an inability to contemplate out-of-the ordinary events, what he terms "Black Swans," referred to as "unknown unknowns" in military parlance.

So what's my point in quoting malapropisms about the future and describing unk-unks? Because it is important to recognize that a cost estimate is a prediction of the future, a bet on what we believe is going to happen. An estimate needs to be much more than just a set of numbers that are used to establish a program's budget. A good estimate provides decision makers with key insights into the risks (and opportunities) of a program. A broad explication of technical and schedule risks are sine qua non features of a sound estimate, but a really good estimate also specifically identifies key program risks. Examples include the validity of critical programmatic assumptions, appropriateness of the acquisition strategy, fluctuations in contractor business base, problems with outsourcing strategy or diminishing manufacturing/material sources, and other Black Swans that I haven't even thought of but that turn out (so obviously in hindsight!) to be important. It goes without saying that identifying all the key risks in advance is really hard.

Eminent statistician George Ball's quote about models aptly describes cost estimates: "All cost estimates are wrong; some are useful." This means that even though it's unrealistic to expect a program to cost exactly what is predicted, a good estimate has value in the information that it provides to decision makers. Besides identifying and providing insights into risks and opportunities, a sound estimate must also explicitly identify key cost drivers and quantify them to an appropriate degree of precision.

What is appropriate? In most cases, the distributions of an estimate (or distributions of the key cost drivers) presented to decision makers should be broader than those that have been proffered in the past. That is, historical data indicate that distributions of outcomes are broad compared to the distributions predicted in typical cost estimates.

So, while the bottom-line numbers given by a cost estimate are necessary to adequately resource a program, in my experience, the most important information that cost estimates provide senior decision makers are insights into the program's risks and cost drivers.

There are other crucial characteristics of a sound estimate that may not be explicitly considered by senior decision makers but need to be considered by the program manager and others charged with reviewing and assessing the estimate. These include the use of sound estimating practices and techniques, such as:

- **Using a variety of techniques to crosscheck results.** Ideally, data are derived from historical actuals that in all cases have been appropriately normalized and adapted so that the data are applicable to the program being costed (much easier said than done).
- **Incorporating all available, relevant information into the estimate when it is presented to decision makers.** This sounds obvious and straightforward, but again, it is easier said than done because of the long time frame required to produce an estimate and because estimates are sometimes structured in a way that makes it difficult to update them quickly.
- **Ensuring the estimate is robust.** For instance, it should provide the appropriate level of detail (which varies depending on the estimate's purpose); it should be created by personnel with sufficient expertise and experience to exercise judgment about the critical factors that influence the estimate; and ideally, it should be scrutinized and evaluated by independent, impartial experts. All these aspects require that appropriate time and manpower be allocated for the estimate.

PMs and others charged with evaluating an estimate should ensure that it:

- Provides explication of risks, both in a general and specific sense.
- Identifies and quantifies key drivers using sensitivity analyses to an appropriate degree depending on the purpose of the estimate and the time frame available for producing it.
- Is based on sound data that are appropriately relevant to the program under consideration.
- Takes into account the most recent information available on the program.
- Provides a sufficiently robust level of detail and has been independently scrutinized.

A PM has the ultimate responsibility to review and assess the validity of a program office's cost estimate and to present it to superiors in a balanced, responsible way. This is no small task, given the DoD and military culture of approaching all problems and issues with an optimistic, can-do attitude. Moreover, with more than enough to do, it is a natural tendency to believe good news about resolution of potential issues, whether it comes from contractors or program office subordinates. While

counterintuitive, devoting some time to continue to examine issues that are supposedly "on-track" is one strategy to provide early warning about problems before they become unmanageable.

A sound cost estimate is a necessary, but not sufficient condition in the process of providing a program with the resources necessary for it to be executed successfully. Ultimately, program success will depend more on the process the cost estimate is meant to inform, namely, establishing the program's budget. Some of the reasons program budgets are often misaligned with the program's best cost estimate are discussed below.

An estimate needs to be much more than just a set of numbers that are used to establish a program's budget. A good estimate provides decision makers with key insights into the risks (and opportunities) of a program.

Misalignment Between Program Budgets and Cost Estimates

The DoD expends enormous effort and funds on program oversight. MDAPs are notorious in this regard, but indeed DoD programs at all levels are renowned for having an extraordinary amount of "red tape." Given the huge effort and extensive deliberation associated with DoD's Planning, Programming, Budgeting and Execution process, one would think that programs, after being approved for initiation and given a budget, would in general be adequately resourced to have a reasonable chance of success. Would that it were so! There are numerous reasons why a program's established budget does not match the most reasonable expectation of what that program will most likely cost. Most disappointing are instances when decision makers should know that the program's budget is likely to be inadequate, yet it is still underfunded during the PPBE process (see, for example, GAO-11-380R, the March 25, 2011, report on the Presidential Helicopter Program and other GAO reports on this program).

The full-funding requirement is meant to ensure that DoD programs have adequate resources budgeted currently and in the out-years to achieve their approved acquisition strategy. Full funding is a DODI 5000.02 regulatory requirement at milestones A, B, and C and is a statutory requirement as part of Title 10 Section 2366 certification at Milestone B. One would infer that programs should remain fully-funded throughout the acquisition process, with their budgets adjusted to reflect the latest best available cost estimate, but unfortunately that is often not the case. Until recently, there was little penalty for certifying a program as Fully-Funded at a major acquisition milestone and then cutting its budget during a subsequent budget cycle, sometimes even the cycle immediately following certification.

To be sure, sometimes the disconnect is the result of revised cost estimates that predict cost growth beyond the budgeted amount. Or the disconnect could result from poor program execution, either in terms of delivering what was promised or obligating and executing funds according to the planned timeline. However, programs executing successfully are also subjected to budget cuts during the budgeting cycle of PPBE that cause them to be underfunded compared to the best available cost estimate, even when the DAE has directed budgeting to that estimate at the most recent milestone.

Structural reasons for this behavior abound: due to its insatiable appetite, the Department has more programs on-going than can be funded adequately (the "bow wave" problem); resource limitations lead some decision makers to rationalize that modest, recurring budget cuts drive efficiency by eliminating waste and non-value added work (when in fact they impair efficiency by subjecting the program to a "death of a thousand cuts"); and, the separate authorities and prerogatives of the requirements, acquisition, and PPBE communities mean that acquisition "decisions" are not necessarily resourced in the budgeting cycle. Finally, over-optimism can derail a program at any time from birth to infancy to adolescence—during the cost estimation process; during the milestone decision if a lower, optimistic cost estimate is selected as the basis for the APB; and during program execution, when our optimistic culture inhibits PMs and decision makers from recognizing and responding to problems that arise within programs.

The Expeditionary Fighting Vehicle (EFV), recently recommended for cancellation by then-Secretary Gates, is an instructive example of a program in which institutional failures related to cost estimating and resourcing occurred that in hindsight seem obvious. (As I also fall squarely into the trap identified by Taleb of inventing a story that perfectly explains

events—after the fact). Initial cost estimates for the SDD phase of the program in December 2000 at Milestone II by the Service and OSD/CAIG were $0.86 billion and $1.24 billion in base year 2007 dollars, respectively. The MDA elected to baseline the program based on the service cost position, which was considerably more optimistic than the CAIG's.

During the EFV's Nunn-McCurdy breach certification process in 2007, other estimating and resourcing shortcomings emerged that contributed to the program's cost growth and failure to meet KPPs. One was that the original cost estimates—both by the Service and the CAIG—were primarily based on analogies to the Bradley Infantry Fighting Vehicle and previous tank programs. The good news was that abundant cost data existed on those historical programs. The bad news was that the technological complexity of the EFV made these historical programs poor analogies, both for the RDT&E and the Procurement phases of the EFV program.

This is, unfortunately, a common problem cost estimators face when estimating revolutionary (vice evolutionary) programs, such as weapon systems that are invisible to the enemy, helicopters that can fly like aircraft, tanks that can ski across the water, and virtually all space and satellite programs. On the resourcing side, like many DoD programs, EFV suffered budget cuts that forced scaledown from the originally designed SDD program. Among the casualties of these budget cuts was a Reliability Improvement Program proposed by the contractor to improve subsystem reliability. Although failure to meet the reliability KPP threshold was the key cause of cost growth, which drove quantity reductions, which drove further cost growth and ultimately put EFV into a Nunn-McCurdy breach situation, it would be disingenuous to assert that better cost estimating and resourcing alone would have prevented program failure.

The oft-occurring bugaboos of technical immaturity and its corollary, over-optimistic timelines, are also cited by the GAO as contributing factors to EFV cost growth. Still, sound estimates and good resourcing are meant to take challenging timelines and the state of technology into account. So when a program fails, it is instructive to begin at the beginning and question the soundness of the estimate and the resourcing decisions, while heeding Taleb's admonition that stories we invent in hindsight that neatly explain events may not have been perceivable in advance.

Conclusion

So what can a PM do to improve the cost estimating and resource allocation processes for his or her program? At first blush, it seems like an insurmountable task, as cost estimates that established the program baseline may have been done years earlier and budget cuts are a systemic feature of our system. The advice I offer falls squarely into that common-sense, non-profound set of good management principles that all PMs are doing their best to adhere to every day. Be skeptical. Be transparent. Be resolute and courageous.

Be Skeptical

When evaluating your cost estimate, be skeptical in a big-picture sort of way. In other words: As PM you don't have the time or even necessarily the expertise to second-guess cost estimating techniques and methodologies or the accuracy and validity of data sources. But it is within your purview to create an environment in which key assumptions and even requirements are regularly re-evaluated to ensure they are still valid. They may have been valid at the time they were established. But conditions change, and sometimes requirements prove to be impossible to meet, and the sooner those changed conditions are recognized and dealt with, the better for your program. If you are lucky enough to be the PM at program initiation, wargame the cost estimate as if you're going into battle and your ASR depends on it. (Ok, APB is the better acronym, but I couldn't resist.)

Be Transparent

In all things, be transparent. Again, this is an obvious positive attribute, but here's what I mean in this context: When you become aware of issues that negatively affect your program's cost, rapidly gather the information, alternatives, and proposed solutions related to those issues so that your leadership and decision makers in charge of resources are informed as soon as possible. There is a tendency in our system to avoid surfacing a new cost estimate that predicts cost growth, particularly as the Nunn-McCurdy breach thresholds are approached. Do your best to ensure that program issues get timely attention, despite the delays inherent in our process.

Be Resolute and Courageous

Be resolute and courageous about the resources required for your program. I realize this is far easier to say than do, and the reality of our system is that PMs are expected to take their "fair share" of cuts and still do the job originally promised. Some people say it demonstrates a lack of credibility to say "If you cut my program by 5 percent, you might as well cancel it." My view, in contrast, is that it is in the best interest of the program and the DoD to quantify to the best degree possible the effect of cuts and change the program accordingly, whether that be by reducing requirements or by extending the program timeline, with the associated increased out-year expenditures that entails. And if a 5-percent cut in a program this year is going to result in a requirement for three times that amount of funds in the future (a conservative estimate!), those effects should be documented and provided to decision makers. To be sure, such an approach requires courage because it is a departure from how the Department has done business in the past, when cost growth was more or less accepted as part of the process. Our belated realization that affordability must be on an equal par with performance necessitates that we make changes to that past way of doing business, so that we produce affordable systems with acceptable rather than exquisite performance within reasonable timelines to support our warfighters.

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Supportability as an Affordability Enabler:

A Critical Fourth Element of Acquisition Success Across the System Life Cycle

Bill Kobren

"Reformed stewardship—driven by improving product support and achieving more cost-effective weapon system readiness outcomes—requires a life cycle management focus, committed leadership, and cooperative efforts from the operational, acquisition, and logistics communities."

—DoD Weapon System Acquisition Reform: Product Support Assessment, November 2009

Acquisition professionals have long recognized achieving program cost, schedule, and performance requirements are essential elements of a successful acquisition program. Often overlooked, however, is a fourth, and in some respects, most critical element on that list.

DoD Directive 5000.01, Enclosure 1, Paragraph E1.1.29 states, "The Program Manager (PM) shall be the single point of accountability for accomplishing program objectives for total life-cycle systems management, including sustainment, survivability, safety, and affordability. ***PMs shall consider supportability, life cycle costs, performance, and schedule comparable in making program decisions*** [emphasis added]. Planning for Operation and Support and the estimation of total ownership costs shall begin as early as possible. Supportability, a key component of performance, shall be considered throughout the system life cycle."

The foundational DoD acquisition directive thus identifies supportability co-equal to cost, schedule, and performance. And not just system acquisition cost either, but *life cycle cost.* Note, too, the last sentence: "Supportability, a

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key component of performance, shall be considered throughout the system life cycle." Not just a one-time thing. Not just during system design, development, or acquisition, but after fielding. In sustainment. During combat operations. When upgrade, modification, service life extension, and yes, system retirement and disposal decisions are being made. In short, *throughout the system life cycle!* Because operations and sustainment costs generally comprise between 65-80 percent of life cycle costs, any credible affordability strategy must tackle these costs.

Why is life cycle systems management such an integral part of both supportability and affordability? There are two primary reasons: sustainment of fielded systems comprises the vast majority of life cycle costs. Just as importantly, the majority of life cycle costs are locked in by early design, development, and manufacturing trade-off decisions. If we're going to seriously attack life cycle costs and positively impact long-term affordability, we must aggressively address operations and support costs at every stage of the life cycle.

In its November 2009 Weapon System Acquisition Reform: Product Support Assessment report, for example, the USD (AT&L) stated:

> If the Department is going to truly reform the business of delivering weapons system capabilities to the warfighter, it must also reform the stewardship of the $132 billion dollars spent each year in product support. Reformed stewardship—driven by improving product support and achieving more cost-effective weapons system readiness outcomes—requires a life cycle management focus, committed leadership, and cooperative efforts from the operational, acquisition, and logistics communities.

What might this mean in practical terms? Suppose for example that in 1986 the Department had set—and a quarter of a century later had achieved—a goal of reducing sustainment costs by half. The cost avoidance alone would be enough to fund the entire investment budget!

Let's Be Clear What We Mean

Merely understanding the importance of life cycle systems management is not sufficient, so let's first be clear on what exactly the term means. Alternatively referred to as life cycle

By unequivocally articulating the Department's commitment to supportability and life cycle management, the die was cast for the PM to now serve as the life cycle manager.

management (LCM) and total life cycle systems management (TLCSM), the Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS) defines the term as "the implementation, management, and oversight, by the designated Program Manager (PM), of all activities associated with the acquisition, development, production, fielding, sustainment, and disposal of a DoD system across its life cycle."

Additionally, a fundamental component of life cycle management is product support. According to the November 2009 Product Support Assessment, "Product support, also referred to as system sustainment, is the package of support functions required to maintain the readiness and operational capability of weapon systems, subsystems, software, and support systems. It encompasses materiel management, distribution, technical data management, maintenance, training, cataloging, configuration management, engineering support, repair parts management, failure reporting and analysis, and reliability growth. Product support considerations, germane to both acquisition and logistics, are necessary throughout the DoD life cycle framework, beginning with early requirements determination and continuing through system design, development, operational use, retirement, and disposal." Product support is indeed a multidisciplinary enterprise.

In a traditional cost, schedule, performance worldview, we risked not having a true life cycle manager. Frequently the program manager's role, responsibilities, and authority tended to diminish once a system was "in sustainment." By unequivocally articulating the Department's commitment to supportability and life cycle management, the die was cast for the PM to now serve as the life cycle manager. The question remains, however: Is the PM truly the life cycle manager? Does he/she have the authorities, incentives, funding, long-term focus, and expertise to effectively serve in this capacity? If not, what needs to change? Who can assist the PM to succeed in this endeavor?

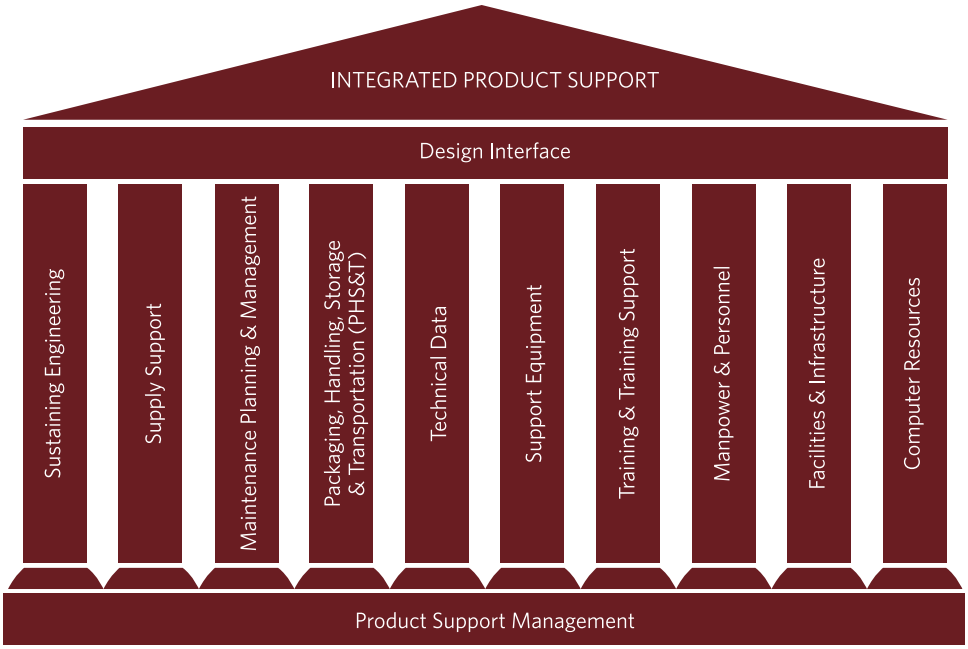
What's Already Been Achieved?

In many respects, "the ball has already been moving ahead" with answers to these questions, through implementation of a series of product support initiatives, policies, and guidance designed to drive life cycle systems management forward and more closely align acquisition and sustainment, including:

- Creation of two seminal guidebooks addressing performance, reliability, and affordability, the October 2003 "Designing and Assessing Supportability in DoD Weapon Systems: A Guide to Increased Reliability and Reduced Logistics Footprint" and the March 2005 "Performance Based Logistics: A Program Manager's Product Support Guide"
- Establishment of key Life Cycle Sustainment Outcome Metrics (including Availability KPP, and Reliability & Cost KSAs) in March 2007 which institutionalize the design, management and sustainment of critical Materiel Readiness outcomes throughout the life cycle
- Transitioning the Acquisition Logistics community into a unified Life Cycle Logistics career field by incorporating product support and sustainment personnel, courseware, and new certification requirements
- Reengineering life cycle logistics competencies from the 2008 DoD Logistics Human Capital Strategy embedded DAWIA certification training
- Deployment of a comprehensive multi-service Logistics Assessment and integrated Air Force and Logistics Health Assessment processes and tools
- Enhancement of the emphasis on outcome-based product support strategies, supportability analysis, and RAM through alignment of *Defense Acquisition Guidebook* Systems Engineering and Life Cycle Logistics Chapters 4 and 5 respectively
- Publishing of a comprehensive DoD Reliability, Availability, Maintainability, and Cost (RAM-C) Rationale Report Manual in June 2009 coupled with the subsequent March 2011 issuance of Directive-Type Memorandum (DTM) 11-003—Reliability Analysis, Planning, Tracking, and Reporting to ensure DoD "acquires reliable and maintainable products that are of high quality, readily available, and able to satisfy user needs with measurable improvements to mission capability and operational support, in a timely manner, and at a fair and reasonable price"
- Issuance and aggressive implementation of recommendations from the wide-ranging November 2009 Weapon System Acquisition Reform: Product Support Assessment report, including new training courses, tools, references, resources, and guidebooks focused on the PSM, Business Case Analysis, Logistics Assessments, and Post-Initial Operational Capability Sustainment Reviews, among others
- Creation of a new sustainment governance structure in an April 5, 2010 "Strengthened Sustainment Governance for Acquisition Program Reviews" USD(AT&L) policy memo
- Issuance of comprehensive Product Support Manager (PSM) guidance in the October 6, 2010 Directive-Type Memorandum (DTM) 10-015 "Requirements for Life Cycle Management and Product Support (as updated in Change 1, dated April 29, 2011)"
- Transitioning the traditional 10 Integrated Logistics Support (ILS) elements into 12 comprehensive Integrated Product

Support (IPS) Elements including new Product Support Management and Sustaining Engineering elements, as well as adding Infrastructure to Facilities and Management to Maintenance Planning (Figure 1).

Figure 1. Integrated Product Support Elements



What More Can Be Done?

These initiatives and many others are an outstanding start by any measure, but there is always more that can be done, particularly in achieving the Department's affordability and readiness goals, and required life cycle systems management outcomes. Several potentially include:

- Effective implementation of DTM 10-015 requirements for life cycle management and product support managers. The components must identify, train, promote, and prepare their best and brightest to serve as PSMs.
- Develop a comprehensive Enclosure 13 to DoD Instruction 5000.02 "Operation of the Defense Acquisition System" to capture key life cycle management and product support policy, emphasizing optimization of system readiness, availability and life cycle cost across the entire system life cycle.
- Broaden the focus on life cycle systems management and product support in DoD training and education beyond just the Defense Acquisition University.
- Institutionalize comprehensive well-thought out means of determining and justifying your program's technical data rights strategy, recently reaffirmed by the Government Accountability Office (GAO 11-469) which recommended DoD "issue instructions for program managers to use when conducting business-case analyses that are part of the process for determining the levels and types of technical data and technical-data rights needed to sustain DoD's systems."
- Demand greater fidelity of outcome-based life cycle product support business-case analysis (BCA) through broad application of processes contained in the new PSM and BCA Guidebooks and rigorous BCA training for the DoD life cycle logistics workforce.
- Increase focus on and training of supportability analysis and sustaining engineering.
- Provide more guidance and tools for tailoring LCM approaches to rapid fielding initiatives and rapid acquisition programs.
- Continue to emphasize long-term sustainability and energy efficiency of weapon systems, including linkage to Section 864 of the FY11 NDAA.
- Continue to inculcate life cycle systems management thinking into the DoD culture. Acquisition and sustainment are inextricably linked. Leverage articles in professional journals such as this, blogs on the Defense Acquisition Portal, and emphasis in interdisciplinary training for acquisition professionals to get the word out.

This is all well and good, especially in view of the fact many of these recommendations and initiatives are already underway. So perhaps a more practical question is "What can I do, as a member of the Defense Acquisition Workforce?" Glad you asked!

What Can I Do as an Acquisition Professional?

First and foremost, recognize supportability as a critical fourth element of acquisition. Be familiar with DoD policy on the subject. Understand LCM practices and principles. Mentor your colleagues, both inside and outside of your career field. If you're a program manager, understand and embrace your responsibilities as life cycle manager. Do not defer, or worse, ignore long-term product support, sustainment, and supportability planning simply because there may be more pressing programmatic or milestone-driven requirements. For non-program managers, understand what LCM is, and embrace the concept, both philosophically and practically. Recognize that you are also responsible for supporting the PM achieve the expected outcomes, bridging the gap between acquisition and sustainment, and planning for long-term product support, often long after the system is out of production.

Each of us, regardless of our functional background or program, must understand and advocate for establishment and successful achievement of the "big four" sustainment metrics (availability, materiel reliability, ownership cost, and mean down time) across the system life cycle. It's not enough to

Do not defer, or worse, ignore long-term product support, sustainment, and supportability planning simply because there may be more pressing programmatic or milestone-driven requirements.

achieve just two or three. An unreliable system, for example, can achieve availability targets with enough spares, but at what cost? The four must be integrated, optimized, well understood, and achievable.

Acknowledge that product support is an integrated, multi-disciplinary endeavor that goes beyond traditional logistics. Commit to getting product support and sustainment requirements right from the beginning, regardless of your Defense Acquisition Workforce career field. Seek to become more knowledgeable of requirements management processes. Take a requirements management course. Seek to better understand how to effectively translate warfighter performance requirements into tailored, affordable, effective product support spanning the entire system life cycle, leveraging outcome-based product support arrangements and the best capabilities of both the public and private sector to achieve that goal. And if you are a life cycle logistician or product support manager, focus with laser-like intensity on continuously reducing the demand for logistics during weapon system design, maintenance planning, and system modifications and upgrades.

Recognize that traditional functional stovepipes risk adversely impacting system readiness, availability, and life cycle cost. Be a strong proponent for interdisciplinary integration, and seek to understand linkages and shared competencies between functional disciplines, particularly, but certainly not limited to the program management, systems engineering, life cycle logistics, contracting, budgeting and cost estimating communities. Regardless of your background or current position, be a strong proponent of supportability and life cycle system management.

Regardless of your career field, embrace aggressive obsolescence and diminishing manufacturing sources and material shortages (DMSMS) mitigation strategies both during development/acquisition and once a system is fielded. Be a strong proponent for technology insertion and continuous modernization. Read and implement the process and practices outlined in the SD-22 DoD Diminishing Manufacturing Sources and Material Shortages (DMSMS) Guidebook.

If you are a life cycle logistician or anticipate becoming a product support manager, aggressively prepare to be the best PSM possible. Avail yourself of requisite training. Become certified at level III in the life cycle logistics career field, but don't stop there. Seek cross-certification in program management, systems planning research development and evaluation/systems engineering, or business-financial management. Broaden your experience on a variety of programs, at a variety of ACAT levels, as well as on systems in early design, development and acquisition, as well as with fielded systems already in sustainment.

Strive to develop and implement best-value, long-term outcome-based product support strategies that leverage performance-based agreements with both industry and government product support providers. Optimize life cycle cost and product support requirements. Seize every opportunity to design out logistics requirements, better meet system requirements, and enhance long-term product support strategies. Remain aligned with your warfighter customer, recognizing they may not always be fully cognizant of the ramifications and cost implications of their requirements. Keep the lines of communication open, dialog constantly, and seek to constantly ensure their product support requirements are captured and well documented in your life cycle sustainment plan and your performance based product support arrangements.

Finally, and in some ways, perhaps most importantly, seek to drive reliability, availability, and maintainability (RAM) into system design and product support strategies throughout the life cycle. Fight for supportability requirements and O&S cost saving initiatives during early system development design trades. Commit to investing in RAM, DMSMS/obsolescence mitigation, advanced diagnostics, prognostics and health management (PHM), technology insertion and upgrades. In many instances, long-term life cycle cost reduction benefits will far outweigh the near-term investment costs. Ensure a comprehensive supportability analysis and regular product support strategy BCAs are performed. Document your life cycle product support strategy in robust and constantly evolving and regularly updated life cycle sustainment plan (LCSP). Resolve not to abandon these critical enablers of achieving supportability requirements when the funding gets tight, system weight becomes an issue, your program finds itself being "taxed" to meet other more urgent requirements, or other competing priorities start crowding in—because these things are almost certain to occur.

At the end of the day, supportability is a key enabler of optimized readiness, affordability, and life cycle cost. Coupled with a robust commitment to life cycle systems management principles and enhanced product support processes and tools, supportability, as the integral fourth element of the acquisition system, serves to facilitate acquisition success across the system life cycle. So let's get on with it!

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Been There, Done That. Got the T-Shirt, Mug, and Hat.

John Krieger ■ John Pritchard ■ Stephen Spoutz

In his Better Buying Power memorandum, the under secretary of Defense (acquisition, technology and logistics) told us: "We must therefore strive to achieve what economists call productivity growth: in simple terms, to DO MORE WITHOUT MORE." He outlined several ways to accomplish that goal, which is not an easy one.

We offer examples of successful implementation from defense acquisitions we have worked. Some might be appropriate for an effort you are pursuing, and others not. Ultimately, you need to be flexible in pursuing the art of the possible. As you do so, we offer a suggestion: get industry partners involved early. They can provide many innovative suggestions. And ultimately, they will be responsible for making your program a success.

So let's start at the beginning of the memorandum and work toward the back. We won't be stopping everywhere; there's not enough space in a single article to do so.

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TARGET AFFORDABILITY AND CONTROL COST GROWTH

Mandate affordability as a requirement.

Specifically, at Milestone A, my Acquisition Decision Memorandum (ADM) approving formal commencement of the program will contain an affordability target to be treated by the program manager (PM) like a Key Performance Parameter (KPP) such as speed, power, or data rate—i.e., a design parameter not to be sacrificed or compromised without my specific authority. At Milestone B, when a system's detailed design is begun, I will require presentation of a systems engineering tradeoff analysis showing how cost varies as the major design parameters and time to complete are varied.

Design-to-cost

One way to achieve this principal action is design-to-cost. Design-to-cost is a concept that establishes cost elements as management goals to achieve the best balance between life-cycle cost, acceptable performance, and schedule. Under design-to-cost, cost is a design constraint during the design and development phases and a management discipline throughout the acquisition and operation of the system or equipment. One of the authors participated in the development of the acquisition strategy for a successful program that included design-to-cost. As part of the request for proposals (RFP), the government laid out in descending order of importance the 23 major requirements that the program hoped to achieve, including specifying nine minimum mandatory requirements that had to be achieved for consideration for award. Based on the budget specified in the solicitation, the offerors were to "draw a line" based on what they believed they could achieve.

INCENTIVIZE PRODUCTIVITY AND INNOVATION IN INDUSTRY

Adjust progress payments to incentivize performance.

As a matter of practice, on all fixed price type contracts, I expect that the basis of negotiations shall be the use of customary progress payments. After agreement on price on the basis of customary progress payments, the contractor shall have flexibility to propose an alternate payment arrangement for the Government's consideration.

In the memorandum, the under secretary writes, "By having determined the projected contract cost, the contracting officer should be able to determine the consideration being offered by the contractor for a more favorable payment structure. The benefits of that improved cash flow shall be documented...."

So, let's talk about cash flow, from the general to the specific.

What is cash flow?

Based on the Random House Dictionary, Dictionary.com defines cash flow as:

> **– noun**
> the sum of the after-tax profit of a business plus depreciation and other noncash charges: used as an indication of internal funds available for stock dividends, purchase of buildings and equipment, etc.

In other words, think of it as the measurement of a company's cash in (paid) and out (spent).

Cash flow: It's what accountants worry about, not something Defense Department program managers and contracting officers need to be concerned about. Right? *Not so fast.* With the call for efficiencies in defense spending comes an emphasis on this "thing" called cash flow; it's not just for accountants any more. The current plan calls for each Service to select a pilot program and for the director of defense procurement and acquisition policy (DPAP) to develop a "cash flow model" to be used by contracting officers when using other than customary progress payments. But don't simply cross your fingers, hope your program is not selected as a pilot program, and then breathe a sigh of relief. No, now is the time to begin to understand cash flow, and increase your situational awareness before a question comes—and believe us, a question will come.

The following discussion is aimed at helping program managers and contracting officers begin to tackle this issue by answering a few questions. What is cash flow? What affects it? And how does a program manager or contracting officer figure out the cash flow status of his/her program and use it to save money?

How do payment arrangements affect cash flow?

The USD (AT&L) memorandum discusses the use of "alternate payment arrangements." What does that mean? Here are some things to consider in understanding payment arrangements and their relationship to cash flow:

- Payments. Money at rest is money available to make more money.
  - —Government to Prime contractor. How long after the prime incurs a cost does the government provide the funds to cover the cost? And how much of that incurred cost? The longer the time between incurring the cost and getting funds, the longer the contractor may have to borrow the money to cover his cost. This adds to the governments costs. Shorter timelines, and greater amounts, are preferred.
  - —Prime contractor to subcontractors. What is the arrangement? The relationship between the prime and its subcontractors may generate cash. Specifically, the longer the time between when the prime gets funding for work the subcontractors have performed and when

the subcontractors are subsequently paid, the longer the contractor(s) could earn interest or invest the funds.

- Lease/Rent/Buy. This is another area that could generate a positive cash flow. For instance, rather than buy a facility a contractor could choose to lease a facility used for their production effort. From a cash flow perspective, the company has very little money invested and, depending on the contractual arrangements it has with both the government and the lease holder, may simply be able to pass the monthly cost to the government; never having to "spend" its own cash.

How does a program manager or contracting officer figure out the cash flow status of his/her program and use it to save money?

A good place to start is with DCMA and DCAA representatives. They have the right technical expertise, access to company financials, and unique insights that will help you to understand an individual contractor's particular cash flow situation.

Inside the program, the program manager and contracting officer can begin to gain an understanding of the contractor's cash flow by examining the payment schedules discussed previously.

- For example, it may be that transitioning from progress payments to performance-based payments between the government and the prime contractor, or the prime and its subcontractors, could reduce the amount of time either the prime or a subcontractor has to "carry" costs (i.e., borrow money) and potentially reduce the overall costs to the program.
- It may also be insightful for a program manager and contracting officer to examine the status of leased vs. owned facilities and equipment. There may be areas where it may be more beneficial to change the current arrangements within the program to decrease expenses.

The concept of cash flow is not new—but, it is likely a new focus area for most DoD program managers and contracting officers. As more is learned from the Services' pilot programs, additional information will come out to help program managers and contracting officers optimize their programs' cash flow. Until then, program managers and contracting officers need to understand the concept, know what affects it, and develop a plan to improve cash flow opportunities to reduce program costs.

Now, a specific example:

Interim Acceptance for Billing Purposes

The production contract for the first two Defense Satellite Communications System (DSCS) III spacecraft began life as a letter contract. As part of the definitization of the letter contract, the Air Force and the General Electric Space Division negotiated an agreement on price on the basis of customary progress payments. However, the contractor proposed that the final agreement contain a mechanism to liquidate progress payments and book sales each year, rather than waiting until the end of a lengthy production period, which would extend over several years. The Air Force and GE reached an agreement to create a special contract requirement and contract line/sub-contract line item structure that would allow the contractor to offer, and the government to accept some CLINS/SLINS on an interim basis for billing purposes, with final acceptance reserved for the completed spacecraft at Cape Canaveral. The Air Force estimate of the reduced contract cost for establishing these "billing points" was $4.5 million. The modification that added the second two DSCS III production satellites contained a similar structure, with similar savings.

PROMOTE REAL COMPETITION

Remove obstacles to competition.

Exchanges with Industry Before Receipt of Proposals

While talking to program managers at the Defense Systems Management College and doing mission assistance, we often hear feedback about the reluctance to conduct one-on-one meetings with potential offerors, usually for fear of protests. Such meetings are specifically allowed by Federal Acquisition Regulation (FAR) 15.201(c)(4), as part of the discussion of exchanges with industry before receipt of proposals. The truth is that protests, although painful, are not particularly frequent, and the government is successful in most protests. During 2010 the entire federal government executed millions of acquisitions, but GAO reports only 2,299 protests, with only 441 having "merit" and only 82 "sustained" (GAO report B-158766, 23 Nov 2010).

There are good reasons to use one-on-one meetings to promote competition. Let's look at one example.

On January 28, 1986, the space shuttle *Challenger* disaster occurred, and instantly, the Department of Defense was largely left with no way to launch critical national security payloads. The Department instituted a National Space Launch Recovery Program to regain that capability, part of which was the Medium Launch Vehicle (MLV) Program, to meet the requirement to launch Global Positioning System (GPS) satellites. The disaster eventually resulted in a 32-month standdown in the shuttle program.

As part of the market research to determine what expendable launch vehicles could meet the MLV requirement, a team including the program manager, chief engineer, contracting officer and others, conducted meetings at facilities of potential offerors across the country. These one-on-on meetings were to determine contractor capabilities and to convince potential offerors of the government's interest in full and open competition.

We went out of our way to include a major contractor that was not currently doing business with the Air Force, but, instead, with the NASA and Strategic Defense Initiative Organization

(SDIO), predecessor of today's Missile Defense Agency. We were told they weren't likely to propose, as they presumed the Air Force was seeking an "Air Force Blue Contractor." Our response was that this would be a fair competition and that the successful offeror would be decided based on the evaluation factors for award in Section M of the solicitation, not whether they were "Air Force Blue."

The contractor, McDonnell Douglas Astronautics Company, did propose and did win. Based upon the program office's independent cost estimate (ICE), that one-on-one meeting may have ultimately saved the government close to $700 million, while providing a production and launch rate that exceeded the requirements of the request for proposals. The latter is an added bonus, as it addresses another of the principal actions in the USD(AT&L) memorandum, *Make production rates economical and hold them stable,* which is located in the major area, TARGET AFFORDABILITY AND CONTROL COST GROWTH.

REDUCE NON-PRODUCTIVE PROCESSES AND BUREAUCRACY

Reduce non-value-added overhead imposed on industry.

Special Termination Cost Clause and Termination Liability

Although we don't like to think about it, one of the potential outcomes of any contract is that the government may chose to terminate for convenience, and incur the associated costs for doing so. Termination costs are those costs that a contractor would incur solely allocable to the termination, including termination settlement and subcontractor claims, or costs amortized over the contract life. Funding this at a contract level appears to be an inefficient cash flow approach as most contracts are never terminated. Under this present approach, contractors reserve sufficient funds within existing contract funding for a potential termination and these funds remain on the contract unused, albeit declining, until contract completion. These funds are finally used up at the end of the contract. One alternative to this way of doing business is to use a Special Termination Cost Clause (STCC).

The authors have used the Special Termination Cost Clause at DFARS 252.249-7000 in several incrementally funded contracts. The clause directs the contractor to exclude from its estimate of costs incurred or to be incurred. The DOD Financial Management Regulation requires the Service or agency to cover expected termination costs from unobligated balances. The STCC is intended to improve cash flow efficiency by reducing the costs that contractors reserve for termination liability, which can amount to millions, or tens of millions of dollars. The clause makes more funds available early in a program's life to do "real work" and accelerate performance. And remember, time is money. Ultimately, barring termination for the convenience of the government, the final end price or cost for the contract remains unchanged.

The Special Termination Cost Clause has the potential to improve contract or program efficiency and effectiveness. Now, just imagine if the Services and agencies used the authority to the maximum extent that they could. Or, better yet, think about how much additional buying power the Department might be able to achieve, if Congress were to allow the establishment of a "termination liability pool." A common pool, based on historical data of the actual number of terminations and costs incurred would be significantly less than having contractors account for termination liability on each and every contract. The use of a single termination pool may have the potential of freeing up billions of dollars and assisting the Department in achieving better buying power.

REDUCE NON-PRODUCTIVE PROCESSES AND BUREAUCRACY

Milestone Budgeting— Requirements and Funding Stability (DEP/MLV)

The authors are hesitant to directly associate this particular discussion with the principal action *Eliminate low-value-added statutory processes.* However, after reading the discussion, readers may draw their own conclusions. Most program managers and contracting officers may consider this to be above their pay grades, but there is great potential for better buying power.

Back in the 1987 Defense Authorization Act, Congress allowed DoD to initiate the use of milestone budgeting for a limited number of programs that were labeled Defense Enterprise Programs (DEPs). DEPs, such as the Air Force's Medium Launch Vehicle (MLV), were placed outside of the normal process by which Congress evaluates and authorizes funding for programs on an annual basis, while the Department's senior decision makers review programs in detail at key milestones. These "enterprise programs" were a recommendation of the Packard Commission, to put Congress on a milestone basis rather than annual reviews. The commission wanted to reduce funding uncertainties of the annual authorization and appropriation processes to enhance program stability. DEPs also had streamlined oversight, which provided a more efficient management structure. On the MLV program, this approach allowed the program office and the contractor to concentrate on program execution, and achieve a remarkable 20 for 20 launch success rate.

Bottom Line

The bottom line is best summed up in the last two sentences of the Better Buying Power memorandum: "I am tasking all of you to absorb this guidance memo and begin acting on it within the scope of your existing authority. There is no time to lose."

It's up to us and our collective ingenuity to make this work!

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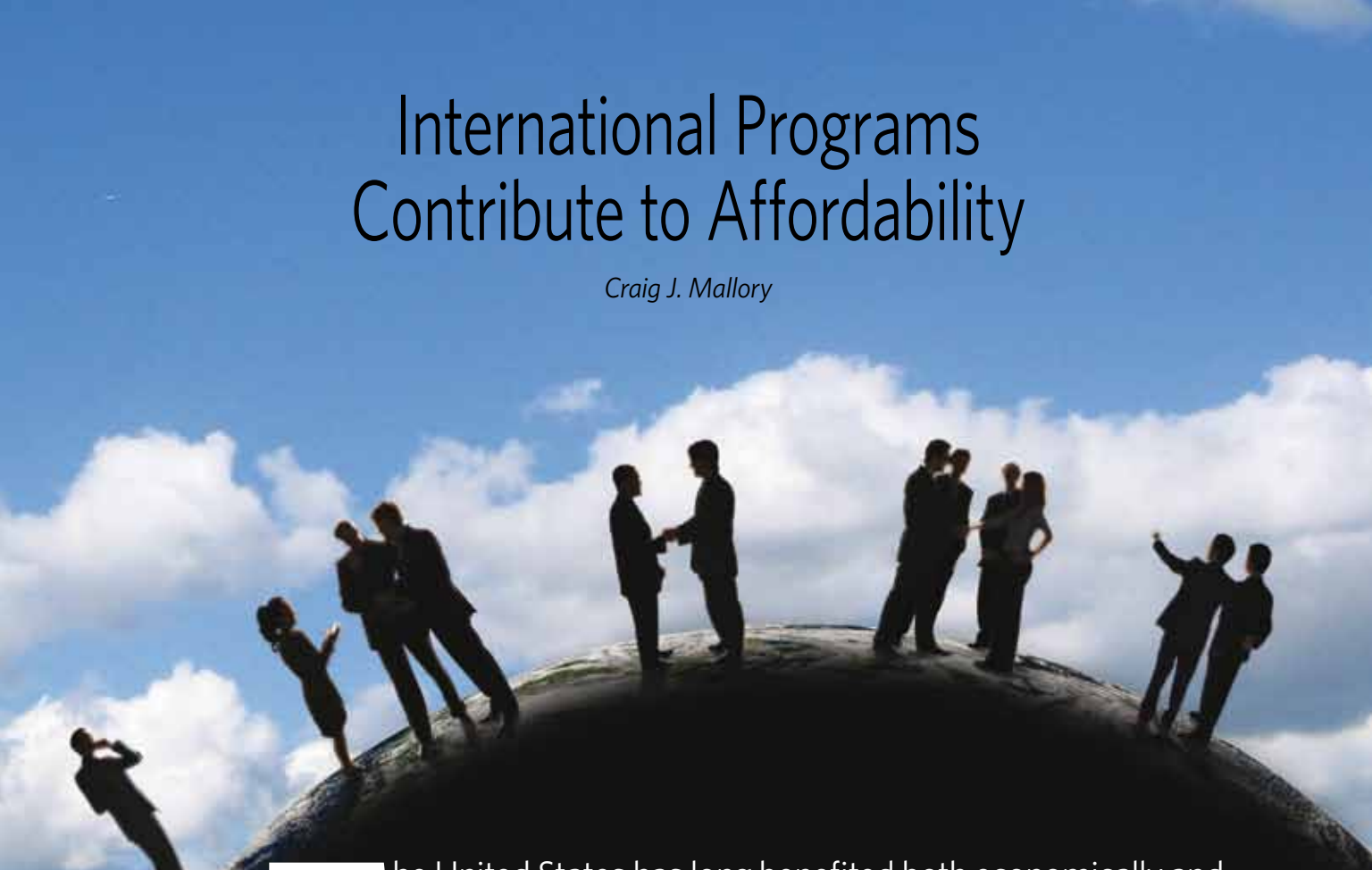
International Programs Contribute to Affordability

Craig J. Mallory



The United States has long benefited both economically and operationally from international acquisition programs. As the Department faces an increasingly challenging economic outlook, it is time to view these activities through a new lens. Whether initiating a new program or managing an ongoing acquisition effort, there are opportunities to enhance program affordability through international cooperation and/or sales. If program managers embrace international programs and plan for them, rather than avoiding them as too difficult or as too risky, we can significantly impact program affordability.

International Cooperative Programs

International cooperative programs are potentially powerful tools in the DoD drive for affordability.

An international cooperative program is any acquisition program or technology project that includes participation by one or more foreign nations, through an international agreement, during any phase of a system's life. In fiscal year 2010, DoD concluded 72 agreements for international cooperative programs at a total value of $2.815 billion, leveraging $1.072 billion of foreign funds—funds that otherwise would have been paid primarily by DoD. These programs are referred to by OSD and the military departments by a variety of terms: armaments cooperation, international armaments cooperation, defense cooperation in armaments, and international cooperative research and development. Unlike other forms of international programs, such as foreign military sales (FMS) (discussed below), DoD is a full partner in an international cooperative program, providing an equitable share of program

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costs using appropriated funds, with the effort jointly managed by the DoD and a partner nation or nations to meet mutual requirements.

The core objectives of international cooperative programs are:

- operational—to increase military effectiveness through interoperability and partnership with allies and coalition partners
- economic—to reduce weapons acquisition cost by sharing costs and economies of scale, or avoiding duplication of development efforts with our allies and friends
- technical—to access the best defense technology worldwide and help minimize the capabilities gap with allies and coalition partners
- political—to strengthen alliances and relationships with other friendly countries
- industrial—to bolster domestic and allied defense industrial bases

International cooperative programs have several important advantages. They can deliver better technology. They can leverage other people's money in both development and production. They will enhance interoperability and are intended to offer a net advantage to the United States. Detailed information on international cooperative programs can be found in the OUSD (AT&L)/IC *International Armaments Cooperation Handbook* and *Defense Acquisition Guidebook* Chapter 11.2.

Foreign Military Sales (FMS)

While a significant number of major defense acquisition programs have an international cooperative program component, more DoD program managers are involved in executing an FMS program. In 2010 alone, the DoD initiated procurement of $25.2 billion of defense articles and services through FMS. FMS programs provide for the transfer of military articles and services to friendly foreign governments and specified international organizations through sales, grants, or leases. They increase the ability of our friends and allies to deter and defend against possible aggression, promote the sharing of common defense burdens, and help foster regional stability. If a partner nation invests in capability that supports U.S. strategic goals in a region, this offers the opportunity for DoD to refocus investment in other, more vital areas thus using limited resources more effectively.

With DoD emphasis on security cooperation and building partner capacity, there have been significant changes to traditional FMS concepts. Title 10, DoD operations and maintenance funding, $6.4 billion in FY 2010, is now being used to build the capacity of partner nations supporting global war on terrorism operations with implementation through FMS-like procedures. The DoD is more aggressively working with international partners to define military requirements and defense procurements to improve their capabilities in relevant areas vice the past practice of taking a hands-off approach until receipt of a letter of request from a foreign government. This new means of providing capability to our allies recognizes that using Title 10 funds to help a partner nation have the capability to contain terrorism within its borders or in its region is more cost effective than having DoD conduct future contingency operations in those same areas.

In addition to contributing to national security and foreign policy objectives and the overall U.S. economy, FMS programs provide direct economic benefits to the DoD in several ways:

- Create economies of scale in both production and sustainment.
- Spread contractor general and administrative costs across a broader business volume, reducing rates for the DoD.
- Maintain production lines after DoD procurements are complete to allow for future U.S. purchases without a break in production capability.
- Share contractor and government sustaining engineering costs.

- Offer DoD the ability to use foreign-funded modifications and improvements for its own needs.

Clear Mandates to Consider International Cooperation

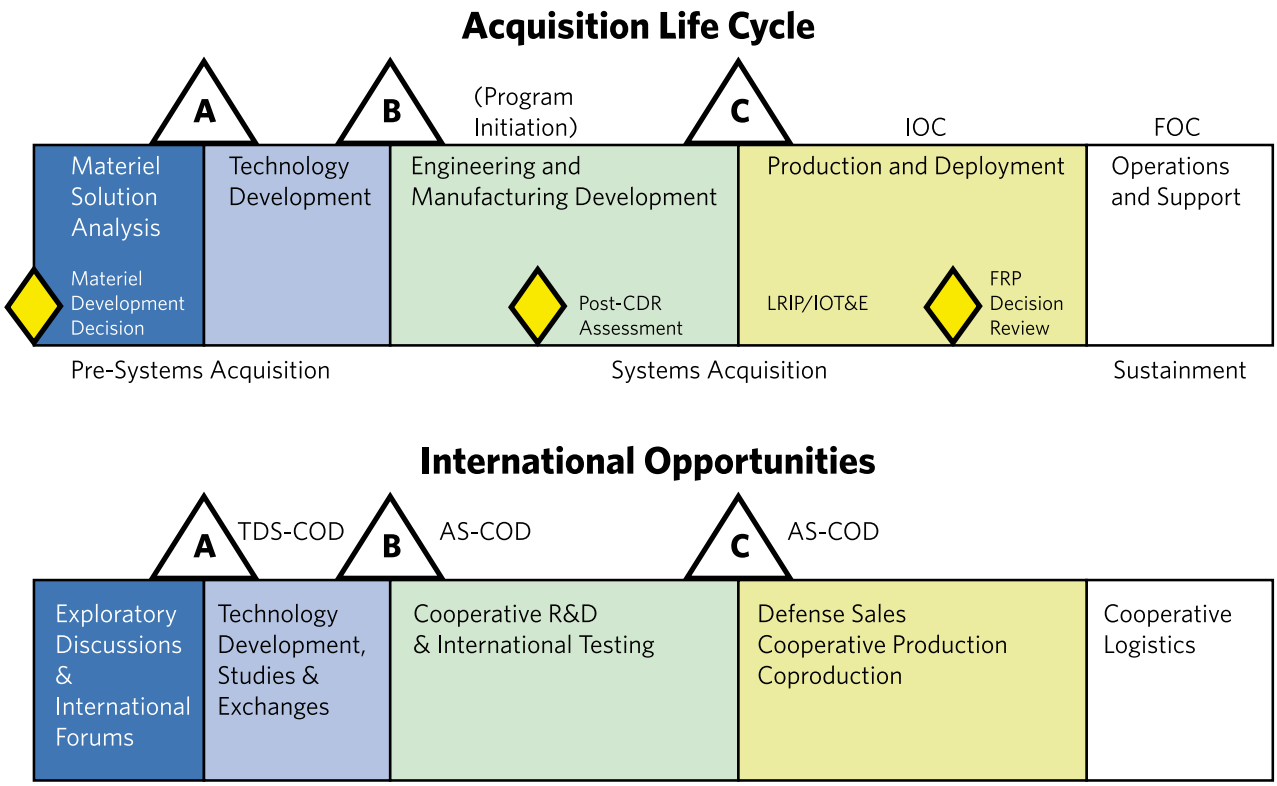
Congress has long seen the potential benefits to the nation from cooperating with allies in systems acquisition and from foreign sales for both economic and foreign policy reasons. To ensure these benefits are realized, there are clear mandates in U.S. law and DoD directives to consider international programs:

- Title 10 U.S.C. 2350a(e) requires an analysis of potential opportunities for international cooperation before the first milestone or decision point on programs reviewed by the Defense Acquisition Board.
- DoDD 5000.01 and DoDI 5000.02 state:
  — Program managers shall pursue international armaments cooperation to the maximum extent feasible, consistent with sound business practice and with the overall political, economic, technological, and national security goals of the United States. (DoD 5000.01, Enclosure 1, paragraph E1.1.1)

From "The Pentagon's Financial Drawdown"
By Gordon R. England,
Former deputy secretary of Defense
(Op-Ed, *The New York Times*, July 14, 2011)

"Washington must do more to encourage the sale of defense equipment to our friends and allies abroad, like the littoral combat ship, the mine-resistant ambush-protected armored vehicle and a host of other combat and combat-support equipment. Manufacturing equipment for the American and foreign militaries simultaneously saves Washington money because more units are produced and overhead costs are shared, and it creates thousands of American jobs. The savings generated by international sales are too big to ignore, yet in too many cases the Pentagon has been only lukewarm in supporting such sales."

Figure 2. Acquisition Phases with Types of International Cooperation



COD = Cooperative Opportunities Document as required under Section 2350a, 10 U.S.C.
TDS = Technology Development Strategy
AS = Acquisition Strategy

— A preference for a cooperative development program with one or more allied nations over a new, joint, or DoD component-unique development program. (DoD 5000.01, Enclosure 1, paragraph E1.1.18)
— The Technology Development Strategy (TDS) prepared for Milestone A or the Acquisition Strategy for Milestones B and C must address international cooperative opportunities. (DoDI 5000.02, Enclosure 4, Table 2-1)
— Program managers shall pursue opportunities throughout the acquisition life cycle that enhance international cooperation and improve interoperability. (DoDI 5000.02, Enclosure 10, paragraph 5.a)

Some International Success Stories

Program	Benefits
F-35 Joint Strike Fighter (JSF)	Eight partner nations contributed $4.2 billion to development, which otherwise would have been paid primarily by DoD; further economies of scale are to be derived through defense sales.
Wideband Global SATCOM (WGS)	Australia contributed $707 million for purchase and launch of the sixth WGS satellite, which was unfunded by the DoD, in exchange for access to WGS constellation.
Excalibur Precision-Guided, Long-Range, 155mm Artillery Projectile	Sweden contributed technology and $67 million to Excalibur's development. Excalibur sales to Sweden and Australia have resulted in production economy-of-scale savings to DoD of over $25 million.
Multiple Launch Rocket System (MLRS)/Guided MLRS (GMLRS)	Long-standing five-nation coproduction program—shared costs of technical data package maintenance, software updates, and improvements including warhead replacement; economies of scale through defense sales to 15 other nations.
C-130J Block Upgrades	Seven partner nations are collaboratively defining and funding C-130J upgrades. Cooperation is saving the DoD one-third the non-recurring costs for development of Block 7 and 8, or approximately $100 million.
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	More than 33 countries have purchased AMRAAM, helping sustain strong logistics support and enhancing the affordability of the system for continued U.S. procurement.

How You Can Use International Cooperation to Enhance Affordability

Opportunities to use international participation in DoD programs to enhance affordability and reduce DoD costs exist in every acquisition phase. Examples include:

- Technology Development Phase
  — Access to foreign technology can reduce technology development costs and risks
  — Use of foreign-developed equipment can reduce or avoid development efforts
- Engineering and Manufacturing Development Phase
  — Research, Development, Test, and Evaluation costs can be shared
  — Foreign test facilities can be used at reduced-costs
- Production and Deployment Phase
  — Non-recurring production costs can be shared
  — Economies of scale can be realized through defense sales or coproduction
- Operations and Support Phase
  — Improved supportability by maintaining a "hot" production base
  — Cooperative logistics can reduce sustainment costs and create overseas support footprints
  — Non-recurring costs for modifications and upgrades can be shared

These are just examples of potential opportunities for international participation which can have significant financial benefits to DoD. They do not represent an all inclusive list; use your imagination when an opportunity presents itself rather than putting it in the "too hard to do" bin.

How Can We Do This Better?

Many U.S. defense acquisition programs have been successful in capitalizing on international cooperation. But there are actions program managers can take to promote and facilitate international programs including:

- Using OUSD (AT&L), military department, and DoD agency bilateral and multilateral forums to discuss potential international cooperation with partner nations.
- Analyzing international cooperation during Analysis of Alternatives activities including structuring market research to facilitate foreign industry participation or conducting feasibility studies with potential international partners.
- Involving U.S. industry in discussion of potential international cooperation to facilitate development of industry-to-industry relationships.
- Conducting a comprehensive cooperative opportunities assessment prior to Milestone A. If a full cooperative development acquisition strategy is impractical, program proponents should consider alternative forms of international cooperation that could be appropriate for the program to include coproduction, FMS, licensed production, component/subcomponent co-development, or incorporation of subsystems from foreign sources.
- Planning for defense sales by early identification of critical program information—information that if compromised,

IACP Levels

Level I Training
CLI 001
International Armaments Cooperation (IAC), Part 1

CLI 002
International Armaments Cooperation (IAC), Part 2

CLI 003
International Armaments Cooperation (IAC), Part 3

CLM 036 (CLI 007 in future)
Technology Transfer and Export Control Fundamentals

Level II Requirements
PMT 202
Multinational Program Management (Resident)

PMT 203
International Security and Technology Transfer/Control (Resident)

Level III Requirements
PMT 304
Advanced International Management Workshop (Resident)

could cause significant degradation in mission effectiveness.

- Developing a program protection plan, incorporating anti-tamper measures, and encouraging modular architectures which facilitate export versions.
- Deliberately planning activities to comply with international security and technology transfer/control requirements.
- Incorporating international considerations in training and sustainment plans.

Support is available to program managers in identifying common requirements, foreign technology and industrial prowess, partner interest in cooperation, and international strategies.

- Each MILDEP has an international program office (IPO) within their Service headquarters responsible for promoting and supporting international cooperation.
- The IPOs also can assist with international "seed funding" from their International Cooperative Research and Development (ICR&D) programs or access to the OUSD (AT&L) Coalition Warfare Program (CWP) and the Foreign Comparative Testing (FCT) program.
- Security cooperation organizations located in U.S. embassies and foreign officials in Washington embassies also provide avenues to investigate international opportunities.

International Acquisition Career Path (IACP)

International programs are an important but complex undertaking. They can help spread the cost and risk of developing and producing complex defense systems across several nations; can allow access to the best technology worldwide; can ensure interoperability between allied and coalition warfighters; and can improve understanding and strengthen ties with U.S. allies. International programs require specialized training of our acquisition workforce to navigate a complicated and often confusing web of legal and regulatory requirements and processes.

Congress recognized the impact that international programs have on our acquisition workforce and acquisition outcomes in the 1990 Defense Acquisition Workforce Improvement Act (DAWIA). DAWIA required the secretary of Defense to designate acquisition-related positions in specified functional areas leading to the current acquisition career fields. Among the acquisition positions that DAWIA specifically identified were those involving "joint development and production with other government agencies and foreign countries." This requirement was not addressed directly until 2007 when USD (AT&L) created the International Acquisition Career Path (IACP) to ensure cognizant officials are more knowledgeable of various processes and the implications for international programs.

The IACP creates mandatory training requirements for Level II and III Program Management Career Field positions providing support to international acquisition programs and technology projects, where more than 50 percent of the work is related to international activities. Positions requiring mandatory international training are being coded in personnel data systems. IACP standards and mandatory training requirements are contained in the DAU catalog in the Program Management Certification and Core Plus Development Guides. It is expected the IACP will evolve to be more inclusive affecting other acquisition career fields.

Summary

International programs represent a major element of the work performed by the Defense Acquisition Workforce, and we have long benefited economically and operationally from international acquisition programs. However, in today's challenging economic environment, if we view international programs through an affordability lens and plan for them, we can achieve even greater benefits for the DoD and enhance the affordability of our defense systems. There are specific actions that program managers can take to promote and facilitate international programs and opportunities for international participation exist in every acquisition phase. Assistance in identifying and pursuing international programs can be obtained from the MILDEP IPOs. OUSD (AT&L) created the IACP with mandatory training requirements to ensure program managers have the proper skills to capitalize on the benefits of international programs and manage these important undertakings.

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Be a Mentor

Wayne Turk

Hopefully, you have or have had a mentor in your career. It may have been for a short while, or it may have lasted your career. Now it's your turn. Coaching and mentoring are not the same but are related. Like coaching, the results of mentoring are applicable to the subordinate, the manager, and the organization.

Characteristics

- Mentoring normally, but not always, occurs outside of a line manager-employee relationship.
- Mentors are usually senior managers in the organization.
- Mentors know the organization's structure, policies, processes and "politics."
- It is at the mutual consent of both parties.
- It is focused on professional or career development; this may or may not be in the protégé's primary area of expertise or work.
- Relationships are personal; a mentor provides both professional and personal support.
- Relationships may be initiated by mentors or created through matches initiated by the organization.
- Relationships cross job boundaries and, in some cases, organizational boundaries.
- Relationships last for a specific period in a formal program but may continue in an informal mentoring relationship.

If you are a lower-level manager, these characteristics don't mean you can't be a mentor. Informal mentoring relationships frequently start early in a career. As a manager, you learn the capabilities and potential of those folks working for you. If you see that potential in an employee and can help them along, why not? It's good for the individual and the organization.

Turk *is a management consultant with Suss Consulting. He is a retired Air Force lieutenant colonel and defense contractor and is the author of* Common Sense Project Management.

In choosing someone or those who you want to mentor, look for junior-level subordinates who exhibit strong leadership skills. Those who display energy, commitment, integrity, good decision-making skills and the courage to take smart risks are your future leaders. They are the folks who you want to help with their career development.

There is a warning, though. Mentoring someone who works directly for you can appear as favoritism. This is especially true if the mentoring leads to special treatment in the workplace. That can cause jealousy or envy in other employees. You don't want that to happen. Those emotions cause nothing but problems in the workplace.

Duties of a Mentor

As a mentor, you want to guide, counsel, support, coach, and encourage your protégé in ways that will help them to expand their abilities, talents, skills, and knowledge. You want to help them understand the "ways of the world," at least as they apply to your organization. You want to share your experience, both good and bad. This is applicable on both the military and civilian side in DoD.

Promote honest, confidential sharing of information, ideas, goals, and thoughts. You need to be honest with your protégé so that they can benefit from what you have to offer. The protégé needs to be honest with you so that you know their thoughts, ambitions, desires, and problems. That honesty will highlight problems and learning opportunities. For example, they're going to make mistakes in the work environment; everyone does. Those are great things to discuss so that your protégé can learn from them. Don't berate them or be judgmental. Just use these mistakes as learning opportunities.

Don't assume every employee wants to be a manager or that every military person wants to be a general. Many people don't want the responsibility or headaches that go with management or moving up in rank. That doesn't mean that you can't help them with their career development. There are other paths to career success. But you have to know what they really want to do before you can help them.

Meet on a regular basis to discuss things. Sometimes because of geographical differences, this is difficult. In those cases telephone calls and e-mails will have to suffice. You need to know what is happening with the person and be able to give them feedback from your perspective. Use those meetings to ask questions, discuss options, share experiences, and any changes that have occurred. Try to let the person you are mentoring take the conversational lead whenever possible. It may take asking questions of the employee to get them talking. Open-ended questions are best.

Give feedback. You want to let your protégé know what you think. It also is the time to discuss options—both for specific events that have transpired in the workplace and for career development. If something has happened in the workplace that causes concern (for either of you), ask them for options on how it might have been handled differently. Talk through the options and the potential ramifications of each. This works well for situations or events that are upcoming, too. For those future events (in fact, for everything), try not to direct, but to guide. In other words, don't tell them what to do, but get them to discuss what they think and, with them, dissect those actions and discuss all the options.

Remember that people learn in different ways. Consider different learning styles. Some people absorb new information best when it's offered verbally. Others prefer documents, while other people want to be shown. Mentoring everyone the same way is not effective. Sometimes differences in age, gender, and background can be factors in how they learn or how they accept information.

You have certain responsibilities as a mentor. You need to assist the employee in developing their talents. You have to maintain your objectivity and balance. Don't focus only on the mistakes or bad things, but also on the good. Allow the person to grow and become more independent. They won't learn if you always tell them what to do. Foster a sense of risk-taking when it is appropriate. As has been discussed before, the "tried and true" doesn't always hack the program. Balance any responsibilities you take on for the person with what they might learn. Finally, do not do their work for them.

The results should be obvious: Good career progression for those with potential. Better managers and better officers. Fewer losses of good people. Those are three big ones. Most of the studies on mentoring show very positive results.

There are also good results for the mentors. Invariably, they learn from their protégés. That makes them better managers, too. Those who mentor, especially in formal programs, are looked with favor by their bosses. Mentors also develop a better network of contacts. And finally, their subordinates respect them for helping.

There are a few bad things about mentoring. A bad mentor can destroy the career of a good worker or cause the loss of that person to the organization. When the mentoring is successful, the person becomes good at what they do which makes them desirable employees/managers for other organizations. I mentioned jealousy and envy much earlier. Those not selected for mentoring, either formally or informally, can feel hurt, discouraged, or disgruntled.

In the end, mentoring a subordinate pays benefits to all involved. The good far outweighs the bad. And besides that, when your protégé is successful, it makes you feel good.

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Illustration by Jim Elmore

Don't Come to the Dark Side

Acquisition Lessons from a Galaxy Far, Far Away

Lt. Col. Dan Ward, USAF

After watching the climactic battle scene in *Return of the Jedi* for the first time, my 8-year-old daughter said, "They shouldn't build those Death Stars anymore. They keep getting blown up." She may be a little short for a stormtrooper, but the kid's got a point.

Yes, the Empire should stop building Death Stars. It turns out the DoD shouldn't build them either, metaphorically speaking. What sort of system fits into this category? I'll resist the urge to give specific examples and instead will simply point out that any enormous project that is brain-meltingly complex, ravenously consumes resources, and aims to deliver an Undefeatable Ultimate Weapon is well on its way to becoming a Death Star, and that's not a good thing.

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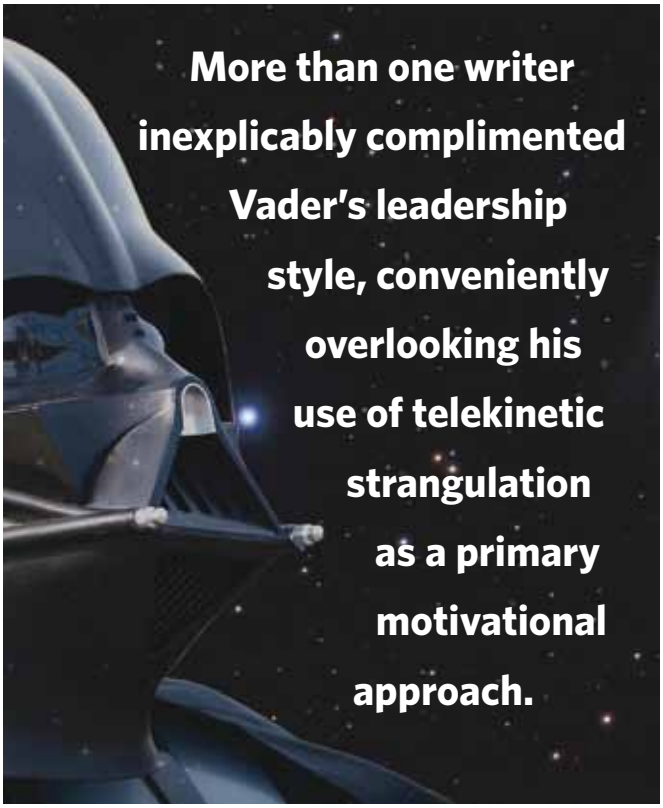

Why are Death Stars a bad idea? The main objections fit into two categories: operational and programmatic. The operational shortcomings of the Empire's doomed battlestations are well known and widely mocked. Their programmatic shortcomings are less well known but worth considering. We'll take a look at both categories.

Death Star Operational Assessment

Introduced in Episode IV, *A New Hope*, the Death Star makes an impressive debut when it vaporizes the planet Alderaan—the one and only time it fires its main weapon. Shortly thereafter, the entire station, with 1.2 million people on board, is destroyed by a single shot fired by a half-trained Jedi. That's what we call a critical vulnerability, and it's the subject of relentless fan disdain. The second Death Star's performance in combat was even less impressive. Despite being much larger than the original one, it was dispatched by the rebels before firing its planet-busting laser even once. So much for being "fully operational."

To be sure, the Death Star is primarily a weapon of intimidation rather than something to be used all willy-nilly. Even the Evil Empire didn't want to demolish more than a handful of planets. So the fact that the Death Star only ever fired one shot may not be that big of a deal. However, the fact that the stations kept getting blown up is a big deal indeed. It's hard to be intimidating if you're a smoking cloud of debris.

One might wonder how such an ostensibly powerful weapon could have such a consistently poor track record and such a gaping weakness. Despite the opinion of certain critics, these shortcomings are not a cheap plot device by a lazy writer. In fact, the Death Star's combination of inadequacy and vulnerability may be the second-most realistic aspect of the entire saga.

Build Them, Do Not

From a design perspective, a system as enormously complex as a Death Star is more than any program manager or senior architect can handle, no matter how high their midi-chlorian count is. There is bound to be an overlooked exhaust vent or two that leads directly to the reactor core. That is just the sort of vulnerability an asymmetric opponent can exploit. In my professional engineering judgment, a flaw of this type was inevitable. As C-3PO would say, the possibility of building such a large and complex system without overlooking something critical is approximately 3,720 to 1! The resulting error may not be as dramatic as George Lucas envisioned, but even a malfunction in the life support system or navigation software can be pretty exciting in its own way.

Death Star Programmatics

The Death Star's lackluster contribution to the fight is reason enough not to build one, but serious problems emerged long before it was declared operational. In *Return of the Jedi,* viewers gain a fascinating insight into the programmatics of Empire acquisitions. In the single most realistic scene in the whole double-trilogy, Darth Vader complains that the second Death Star construction project is ... behind schedule. In fact, much of the drama in Episode VI revolves around this delay.

Consider the implications of pop culture's most notorious schedule overrun. In the Star Wars universe, robots are self-aware, every ship has its own gravity, Jedi Knights use the Force, tiny green Muppets are formidable warriors and a piece of junk like the Millennium Falcon can make the Kessel Run in less than 12 parsecs. But even the florid imagination of George Lucas could not envision a project like the Death Star coming in on time, on budget. He knew it would take a Jedi mind trick beyond the skill of Master Yoda to make an audience suspend that much disbelief.

Even worse, it turns out getting a moon-sized project back on track requires the personal presence of a Sith Lord. Let me assure you, if your project's success depends on hiring someone whose first name is Darth, you've got a problem. Not just because Sith Lords are make-believe, but also because they're evil.

I've Got A Bad Feeling About This

If you count the 14 hours I spent rewatching all six movies, I did way more research for this article than any other project in recent memory. During the phase of research that did not involve popcorn, I was surprised to discover several blogs and published articles praising Darth Vader for his programmatic prowess.

You'd think it would go without saying that Vader is not a great example of anything other than redemption. From the time he

puts on that black helmet until his (spoiler alert!) heart-warming death scene, he's a complete baddie. And yet, it turns out many fans have drawn unfortunate lessons from this character.

An article in *Project Magazine* titled "If His Day Rate Is Reasonable, Get Darth Vader" commended Vader's ability to turn around an ailing project. Another program management professional wistfully wrote, "If only most project managers could have the presence and command the respect that Darth Vader did..." Um, have you seen these films? I don't think we really want PMs to walk around in capes and black armor. Sure, I've known people who thought they were on par with Vader, but I assure you, his path is not one we should follow. I'm pretty sure it leads to suffering.

A few writers praised Vader's strong communication skills, pointing out that he conscientiously "ensured the Emperor was kept up-to-date with regular progress reports." In a similar vein, I'm told Mussolini kept the trains running on time. Even if that were true (and it's not), it doesn't make him a good role model.

More than one writer inexplicably complimented Vader's leadership style, conveniently overlooking his use of telekinetic strangulation as a primary motivational approach. One misguided soul described Vader as "an authoritative figure who commanded respect." A more accurate description might be "a murderous tyrant who commanded obedience." There's a difference.

Happily, a blog commenter with the unlikely nom de net of Luke had the wisdom to point out, "All projects developed by Dark Lords will end up like the Death Stars." By that I presume he meant "glowing fields of space junk," but it's possible he also meant "over budget, behind schedule and blown-up before Act II." Online Luke is probably right: Dark Lords build Death Stars. I suspect the inverse is also true—building Death Stars makes program managers end up like Dark Lords. If so, that's one more reason not to do it.

A Jedi Craves Not These Things

Now, the commentaries I quoted were surely at least partially tongue-in-cheek. However, there seemed to be a sincere underlying belief in many cases that a) the Death Stars were awesome engineering projects and b) Darth Vader was a good leader who got stuff done. I can excuse enthusiastic fanboys and fangirls for holding these beliefs, but as professional military technologists, we know better.

Consider the fact that even the Empire, with all its vast resources and the full power of the Dark Side, could only build one Death Star at a time. Building two at once was clearly more than it could handle. This reminds me of Norm Augustine's famous prediction that at some point, the entire DoD budget would purchase just one aircraft for all the Services to share. The Empire apparently arrived at this singularity long, long ago. I'm not convinced this achievement represented real progress.

The truth is, Death Stars are about as practical as a metal bikini. Sure, they look cool, but they aren't very sensible. Specifically, Death Stars can't possibly be built on time or on budget, require pathological leadership styles and, as we've noted, keep getting blown up. Also, nobody can build enough of them to make a real difference in the field.

The bottom line: Death Stars are unaffordable. Whether we're talking about a fictional galaxy far, far away or the all too real conditions here on Planet Earth, a Death Star program will cost more than it is worth. The investment on this scale is unsustainable and is completely lost when a wamp-rat-hunting farmboy takes a lucky shot. When one station represents the entire fleet (or even 5 percent of the fleet), we've put too many eggs in that basket and are well on our way to failing someone for the last time.

The answer isn't to build more, partly because we can't and partly because the underlying concept is so critically flawed. Instead of building Death Stars, we should imitate the most successful technology in the saga: R2-D2.

The Droids We're Looking For

My extensive research uncovered an interview where George Lucas identified R2-D2 as "the hero of the whole thing." I found this comment startling at first, because in all my boyhood hours of playing Star Wars, nobody ever wanted to be an astromech droid. We all wanted to be Luke. And yet, a closer look at the films shows Artoo has an impressive tendency to save the day, in scene after scene. Whether it's repairing the Millennium Falcon's hyperdrive, destroying a pair of Super Battle Droids, conveying a secret message to old Ben Kenobi or de-

livering Luke's light saber at the critical moment on Jabba's Sail Barge, he's always got a trick up his proverbial sleeve.

When a young Anakin snuck Padme off Coruscant and reassured her by saying "Don't worry, we have Artoo with us," he was not being ironic. No other character, biological or mechanical, is quite so dependable. If I was assaulting a Death Star in an X-wing fighter, you bet I'd want a good R2 unit on board.

Our Only Hope

Yes, there are plenty of flaws in the Star Wars films—I'm looking at you, Jar Jar Binks—but casting R2-D2 as the hero isn't one of them. Just as the Death Stars' vulnerability and inadequacy are perfectly realistic, the superior operational performance of a simple droid corresponds to real-life experience. Time and again, war-winning weapons tend to be simple, inexpensive and small.

An astromech droid's simplicity makes it reliable, and its long history of use in battle makes it robust and widely useful. Consider Artoo's restrained design. He doesn't have fancy language processors; beeps and squeaks suffice. He doesn't have arms or even a face. Artoo is pure function. He has no unnecessary features, no superfluous parts. He's not even very tall, proving once again Yoda's dictum that size matters not.

Consider this: A Death Star is an Empire weapon that aims to intimidate opponents into submission. Droids are Republic technology. They don't intimidate anyone. Instead, they earn their keep by being useful and practical. Droids are about finesse, while Death Stars are about brute force. And given the current world situation, finesse is clearly what we need.

Droids aren't expensive; their requirements aren't overstated. One might argue that a droid can't do what a Death Star does, but then again, the Death Stars didn't do very much when all was said and done. In the final accounting, a droid like Artoo does more than it was designed to do, while a Death Star ends up doing less. Much less.

If you want to keep your limbs intact, let the Wookie win. And if you want to develop and deliver effective weapon systems, build droids instead of Death Stars. The key is exercising design restraint, focusing our requirements on the essential requirements rather than the endless list of desirements, living within our budget and resisting the temptation to extend the schedule. Sure, it's hard to tell the Emperor no when he insists on building yet another Death Star, but since the Force is imaginary, chances are good you won't get zapped with lightning for suggesting an alternative approach.

There are all sorts of ways to simplify a design, to reduce a set of requirements to the bare minimum, to make sure we build what we can afford. Don't believe such a thing can be done? That is why you fail. But those who do believe will find the system they built just might be "the hero of the whole thing."

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Defense AT&L is a bi-monthly magazine published by DAU Press, Defense Acquisition University, for senior military personnel, civilians, defense contractors, and defense industry professionals in program management and the acquisition, technology, and logistics workforce. The magazine provides information on policies, trends, events, and current thinking regarding program management and the acquisition, technology, and logistics workforce.

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Deadlines

Issue	Author Deadline
January-February	1 October
March-April	1 December
May-June	1 February
July-August	1 April
September-October	1 June
November-December	1 August

If the magazine fills before the author deadline, submissions are considered for the following issue.

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