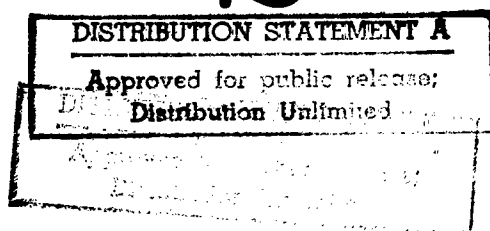


12

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Review

VOL. 4

NO. 4

- | | | |
|--|---|-----|
| Dr. Ronald D. Kankey
Dr. Jan P. Mucsyk
Col. Neal M. Ely, USAF | Focused Graduate Education
<i>An Invisible But Real Competitive Edge</i> | 367 |
| J. Michael Brower | Outland
<i>The Vogue of DoD Outsourcing and Privatization</i> | 383 |
| Maryjo Hall, Ph.D. | Changing the Way We Assess Leadership | 393 |
| Col. Randy Davis, USAF
LTC Bill Phillips, USA
Lt Col Bud Vasquez, USAF | The Phoenix Rises | 411 |
| Deanna J. Bennett | A Program Manager Talks
<i>What Contractors Should Know</i> | 435 |
| Gary M. Bender
Donna M. Duganiero
Clark O. Spencer | Estimating the Health Hazard Cost of Army Materiel
<i>A Method for Helping Program Managers Make Informed Health Risk Decisions</i> | 443 |



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Fall 1997
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TABLE OF CONTENTS

OPINION

**367 - FOCUSED GRADUATE EDUCATION:
AN INVISIBLE BUT REAL COMPETITIVE EDGE**

Dr. Roland D. Kankey, Dr. Jan P. Muczyk, and Col Neal M. Ely, USAF

The future mission of the Air Force will require advanced technology so that a smaller force can accomplish more. Our acquisition corps must be intellectually capable, well educated, and trained. Focused graduate education will be essential to sustain this effort.

383 - OUTLAND: THE VOGUE OF DOD OUTSOURCING AND PRIVATIZATION

J. Michael Brower

Examine outsourcing and privatizing carefully before use. The effects may devastate the defense industry workforce and savings may evaporate over the long term.

393 - CHANGING THE WAY WE ASSESS LEADERSHIP

Mary-jo Hall, Ph.D.

Change at the organizational level, the team level, and the personal level is required if the acquisition community is to operate within a constrained budget and with fewer people. The author describes a method to assess the capability of current leadership, and proposes a theory of leadership appropriate to the times.

LESSONS LEARNED

411 - THE PHOENIX RISES

Col Randy Davis, USAF, LTC Bill Phillips, USA, and Lt Col Bud Vasquez, USAF

The troubled C-17 "Globemaster III" airlifter rebounded from the brink of extinction to become a model of reduced-cost and ahead-of-schedule production through the determined use of integrated product teams, the program executive officer system, and the process approach to manufacturing.

**435 - A PROGRAM MANAGER TALKS:
WHAT CONTRACTORS SHOULD KNOW**

Deanna J. Bennett

Despite the drive for open communication and application of across-the-board rules, contractors distrust the government's acquisition process, penalize themselves through misunderstanding, and make tactical and factual mistakes in proposal preparation and discussion processes.

TUTORIAL

**443 - ESTIMATING THE HEALTH HAZARD COST OF ARMY MATERIEL:
A METHOD FOR HELPING PROGRAM MANAGERS
MAKE INFORMED HEALTH RISK DECISIONS**

Gary M. Bratt, Donna M. Doganiero, and Clark O. Spencer

The authors discuss their model, designed to help the U.S. Army estimate weapon system health hazard costs, based on the probability of a hazard occurring and the severity of that hazard. The model provides health risk assessment and management, eliminates or controls health hazards, and controls life-cycle costs. Application to other prevention disciplines within acquisition will provide decision makers with valuable quantitative information regarding cost avoidance.

473 - ARQ GUIDELINES FOR CONTRIBUTORS

477 - DSMC'S HOME PAGE

FOCUSED GRADUATE EDUCATION: AN INVISIBLE BUT REAL COMPETITIVE EDGE

Dr. Roland D. Kankey, Dr. Jan P. Muczyk, and Col Neal M. Ely, USAF

The future mission of the Air Force will be diverse and complex. Advanced technology will play an increasingly prominent role; a smaller force must accomplish more. To support this mission, our acquisition corps must be intellectually capable, well educated and trained. Focused graduate education will be essential to sustain this effort.

The Air Force has long recognized the value of quality education, as is evident from the following axiom: "Success in war depends at least as much on intellectual superiority as it does on numerical and technological superiority" (Department of the Air Force, 1992). In this era of right-sizing and trying to do more with less, the oft-uttered phrase "work smarter, not harder" seems to underscore the importance of education. In other words, the Air Force's competitive edge in the future, both on the battlefield and in system acquisition, will depend in a large measure on that part of the human anatomy that rests on the shoulders.

For those of us in the field of acquisition, this would appear to be particularly applicable given the direction in which the Air Force (and for that matter every ser-

vice) is headed. In the words of the former Secretary of the Air Force, the Honorable Sheila E. Windall, and the previous Chief of Staff, General Ronald R. Fogleman, the Air Force faces a period of profound change.¹ Although it is easier to explain the past than to predict the future, there are some assumptions that can reasonably be made about certain aspects of this change.

In the future, the activities involved in executing the Air Force's mission (which includes equipping and training) will become more diverse and complex, and may involve operations and acquisitions that are novel and nontraditional. While the Air Force (and the Department of Defense [DoD]) of the future will most likely be smaller, based on the experience of the past few years the tempo of operation will likely be faster paced and less predictable

than in the old Cold War environment. Forces may be deployed more frequently, and under the new Air Expeditionary Force concept, they will probably be deployed in smaller, nonstandard, unit-equipped deployment packages (Fogleman, 1996). Advanced technology, in the form of weapon systems, information management, etc., will play ever more prominent roles, and in all cases, we in acquisition will have to provide reliable, affordable, and state-of-the-art equipment and information systems to support the warfighter. All these elements are consistent with the Air Force's new strategic vision of "global engagement" (Secretary of the Air Force, 1996).

As the operational tempo increases, enormous pressures exist to reduce defense spending in concert with deficit reduction and budget balancing. Yet as a result of a decade of steady decline in the defense budget, much of the activity sur-

rounding what budget authority is available will involve how to ramp up and maintain adequate spending for force modernization (to provide systems needed for potential future conflicts) while maintaining acceptable present and future force structure (White, 1996). Acquisition reform and technology will play a significant role in how we acquire new weapon systems for this modernization, and initiatives such as clear identification of DoD core capabilities and the transfer of specialized military technology to the civilian sector will enhance the efficiency and effectiveness in both the military and commercial industrial bases.

Most recently, the Chairman of the Joint Chiefs of Staff published *Joint Vision 2010* (1996), his template for the operational evolution of the Armed Forces, which acknowledges that technologically superior equipment has been critical to the success of our forces in combat. We will need a

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responsive research, development, and acquisition process to properly incorporate these new technologies. The need to overcome bureaucratic inertia, to change the way we do business, is cited as a requirement for future military success (LaBerge, 1996). It is well understood that education is one of the few acceptable methods to overcome inertia and change people's behavior. Our acquisition corps must be intellectually capable, well educated and trained, and be able to create an acquisition process to match the rapidly developing acquisition reform initiatives and legislation, as well as the emerging industrial base and system requirements of the future. In this future, dramatic changes will be wrought by technology: changes in our weapons systems, changes in our acquisition processes, changes in our information systems and information management, and changes in our logistics. As indicated in *Global Engagement*, our core competencies are the combination of professional knowledge, airpower expertise, and technological know-how that produces superior military capabilities (Secretary of the Air Force, 1996). Weapons system acquisition specialists will be key to incorporation of modern and developing technologies into operational weapon systems and the acquisition of these systems at affordable prices.

Acquisition functions will not be exempt from increased "right-sizing" and budgetary pressures as we attempt to balance support for the current and future warfighter with achievement of a leaner infrastructure. In addition, activities that occur away from the flightline will be closely scrutinized for civilianization, privatization, and outsourcing. The impact of all this will create changes in the size

and composition of the force, as well as in certain activities performed by remaining personnel. The mission of the Air Force, although it may appear to look different, will endure or perhaps even grow. Therefore, a smaller number of individuals will be expected to perform a larger number and greater variety of tasks and duties, and they will have less time to prepare for them.

A pressing need will exist for a force multiplier to help ensure our future success, both on and off the battlefield. This will be especially true for the rapidly evolving acquisition career field to help those in it become "the world's smartest buyers." Those responsible for acquiring and sustaining next-generation systems will need the intellectual acumen to "name that tune" after hearing just two or three notes. This article will discuss graduate education as a component of the force multiplier, and the need for appropriate focus in graduate education.

"The need to overcome bureaucratic inertia, to change the way we do business, is cited as a requirement for future military success" (LaBerge, 1996).

EDUCATION AND TECHNOLOGY ARE FORCE MULTIPLIERS

The most effective force multiplier is really a multivariate equation consisting of an able, motivated, and well-led workforce with appropriate training and education, and supported by state-of-the-art technology (Muczyk & Hastings,

1985). A small force leveraged by the above-mentioned enabling factors can defeat a much larger force that lacks one or more of the aforementioned elements. The Israeli experience since 1947 and the U.S.-Coalition defeat of a larger Iraqi force in the Persian Gulf War constitute two excellent examples of the power of the force multiplier equation.

The concept of education as a "force multiplier" has broad general applicabil-

"...it is the rapid transformation of innovation into products and services through 'management' technology that provides the competitive edge in the marketplace."

ity and is not unique to just the operational military. For instance, an analogy can be drawn between the future need for this force multiplier by the Air Force (including its

acquisition function), and the need for a similar force multiplier in the private sector, if it is to remain healthy and competitive in the future. Simply put, success for both will depend on a qualitative rather than a quantitative edge. The Air Force is moving to a smaller, higher technology force, where success will be a result of qualitative rather than quantitative factors.

On the economic front, the United States cannot compete with China, India, Indonesia, Mexico, and other developing nations as far as labor-intensive industries are concerned (Higgins, 1991). If the United States is to enjoy a promising economic future, it must concentrate on high-technology, communications-oriented, knowledge-intensive industries. These industries require a well-educated, technical workforce (i.e., the force multiplier).

Without this, the nation will lack a competitive edge, and will wind up exporting its wealth to more productive nations (Dunham & Pierce, 1989). This is why so many successful companies emphasize quality education through reimbursement programs. This creates a powerful win-win situation for the company, its employees, and its stockholders. This relationship is recognized and understood within the private sector, and that is why individuals who have a quality technical education are doing better than ever before, while those who do not are losing ground (Howard, 1995).

THE SALIENCY OF MANAGEMENT TECHNOLOGY

Typically, the term *technology* conjures up the realm of Thomas Edison and his lab—that is to say, "physical" technology. Yet there is another technology that is becoming even more important, and that is "management" technology. By this we mean the organizational patterns and management systems that society develops to administer key institutions. In light of the difficulty of protecting physical technology, international patent agreements notwithstanding, it is the rapid transformation of innovation into products and services through "management" technology that provides the competitive edge in the marketplace. Japan's economic miracle can be largely attributed to its superior management technology, which creates the illusion that the Japanese are more innovative on the physical technology frontier than they actually are (Muczyk & Hastings, 1985). In other words, leading-

edge management technology makes it possible to exploit physical technology and provide the necessary cycle time advantage (Muczyk, 1990; LaBerge, 1996; Clubb, 1996).

On the military front, we simply must come to terms with the reality that multinational and transnational corporations produce most of the technology, and practically anyone can obtain it either directly or through third parties. Once the technological genie is released, no amount of secrecy and effort can put it back in the bottle. Therefore, quickly transforming available technology through the most efficient management systems and organizational patterns into superior weapon systems is paramount. The importance of management technology is further highlighted by the necessity to obtain the biggest "bang for the buck" in the systems we are acquiring.

GENERIC VERSUS FOCUSED EDUCATION

On the educational front, the value of focused versus generic graduate education is being hotly debated not only by the private sector, but also by the military (Air Force Institute of Technology [AFIT], 1996).² To be certain, the value added of focused education is quite elusive and difficult to quantify. Some examples are in order. There is an abundance of successful flag officers who are products of undergraduate and graduate civilian programs. Does that imply that the more expensive military academies are a waste of taxpayers' funds? Moreover, most corporate executives receive their degrees from public universities, and not all of the degrees are in business administration.

Should parents stop sending their offspring to the more expensive private institutions, and should we discourage students from attending business schools? In like manner, one could point to numerous successful military logisticians who obtained their graduate education in civilian institutions. Thus, the central question becomes: Does the promotion rate in the world of work constitute the only or the best criterion for evaluating education? We think not, and more will be said on this point later. Since it is in vogue to look to the private sector for "best practices," we shall oblige.

"On the military front, we simply must come to terms with the reality that multinational and transnational corporations produce most of the technology, and practically anyone can obtain it either directly or through third parties."

FOCUSED GRADUATE EDUCATION AS A BEST PRACTICE

Historically, U.S. firms relied on generic education. The industry- and company-specific knowledge and practices were to be obtained through on-the-job experience and the training provided by the company through a variety of continuing education instrumentalities. Even business schools were expected to provide only the knowledge and practices that were common across organizations; while everything else was the responsibility of the employer. The "big six" accounting firms provide a superb example of that model through their training centers that offer a comprehensive catalog of courses that prepare young people who already

possess generic accounting degrees to become public auditors, tax specialists, or consultants. Certainly, there have been exceptions all along, with the best example being the General Motors Institute, which provided focused degrees for General Motors employees.

More recently, though, many U.S. corporations have concluded that focused education is the best business practice, even though initially it is more expensive, and are resorting to teaming arrangements with civilian graduate schools in order to tailor management programs to the specific

The ability to tackle subjects of immediate relevance in a direct manner holds much appeal to most managers, regardless of nationality or geography (Bradshaw, 1997; Griffith, 1997).

needs of their organization. This has compelled a number of business schools to move out of their ivory towers to forge partnerships with corporations, resulting in multifac-

eted, long-lasting, and strategic alliances that fuse business practice and business education. A recent report estimates that companies with management education and training divisions called colleges, institutes or universities increased from 400 to more than 1,000 between 1988 and 1995 (Hoffman, 1997; "The Corporate University Boom," 1996; "Corporate Universities Grow in Stature," 1997). Among the best known are Motorola University and the MBA program offered by the Arthur D. Little School of Management.

The aforementioned trend is evident abroad as well, since international executives also believe that focused education

makes a larger and more immediate impact on the organization, because it deals with the company's specific problems, solutions, opportunities, and threats. The ability to tackle subjects of immediate relevance in a direct manner holds much appeal to most managers, regardless of nationality or geography (Bradshaw, 1997; Griffith, 1997). Likewise, teaming arrangements between a private firm and an educational institution permit responsiveness to the ever-changing needs of the firm, thereby providing a competitive edge.

A 1996 survey of organizations participating in focused education programs revealed that the impetus provided by rapid change is largely responsible for the customization trend, with the desire to align education with an organization's goals, to spread organizational culture, and to enhance the employability of organizational members ("The Corporate University Boom," 1996). The same survey administered in 1997 produced the following list of benefits from focused education: 1) enhanced job performance (37 percent); 2) communication of mission/vision and values (31 percent); 3) development of a world-class leadership program (24 percent); 4) establishment of a systematized education process (18 percent); and 5) the educational programs as an agent of change for the organization (13 percent) ("Corporate Universities Grow," 1997). It is interesting to note that in the latest survey a bottom-line impact was cited most frequently as the most valuable contribution of focused education.

ORGANIZATIONAL CULTURE AS AN IMPORTANT PERFORMANCE VARIABLE

An increasing number of executives are recognizing the importance of organizational culture, and are expending significant resources to create and maintain a culture that reinforces organizational goals and objectives. Focused education is viewed by certain executives as a more effective vehicle for propagating a desired culture than is generic education, and for good reason. Putting a significant number of members of the same organization through the same intense, extended experience not only inculcates shared values, but reinforces them as well. After all, shared values are the stuff of which culture is made.

The Air Force's recognition of the importance of organizational culture played an important role in its creation of the new Air and Space Basic Course. Additionally, now that the Continental United States (CONUS) C-130 community and operational support airlift have been reassigned to the Air Mobility Command (AMC), the need for the development and growth of an AMC culture has been accentuated. One of the vehicles to accomplish this goal is through the AFIT Master of Air Mobility Degree at the Air Mobility Warfare Center, Fort Dix, NJ, which is embedded in the Advanced Study of Air Mobility Program (Larsen, 1997).

THE DEFENSE DEPARTMENT ANALOGY

For more than 50 years, the U.S. military has relied on both above-mentioned models. Some officers were sent to civilian universities for generic degrees. These

officers were then focused through professional continuing education (PCE) courses as well as through on-the-job experience. Others were sent to organic graduate schools—AFIT and the Naval Post Graduate School (NPS), with reduced subsequent PCE obligations. The Army did not operate its own organic graduate school but uti-

lized both AFIT and NPS, and for certain programs, such as Financial Management, it partnered with a civilian university. One could even

"Focused education is viewed by certain executives as a more effective vehicle for propagating a desired culture than is generic education..."

make a cogent case that educational diversity contributed to the preeminence of our armed forces. The rationale for this dichotomy was straightforward. In those areas where the differences between civilian and military applications were small, a generic degree was acceptable. Otherwise, an organic degree was preferred.

Military establishments of other nations also rely on organic education. One of the better known is the United Kingdom Ministry of Defense Graduate School at Portsmouth. Interestingly, the Graduate School of Logistics and Acquisition Management at AFIT provides not only a model for some of our allies, but also the "seed corn." That is, certain countries send officers to AFIT, who, after graduation, go back as instructors and administrators of their own organic schools. In addition, they use many of the course materials to which they have been exposed at AFIT. Brazil serves as the best example.

THE NEW ORDER

Since the disintegration of the Soviet Empire, practically everything has become budget driven and the “80 percent solution” is acceptable (i.e., since the last 20 percent of performance is the most difficult and expensive to obtain, in the absence of a clear and present danger, 80 percent of performance is good enough). Few would argue that an organic graduate school adds value. The crux of the debate, however, revolves around the question: Does the value added justify the greater cost?

We need to be quite candid for the moment. Using promotion rates as a proxy measure of the value of focused organic versus generic civilian education is hazardous indeed, because the nexus between

promotion rates and contribution of organizational members is based on a considerable leap of faith. On the other hand, alternative criteria cannot be

“Using promotion rates as a proxy measure of the value of focused organic versus generic civilian education is hazardous indeed...”

defended with incontrovertible evidence either. Let us illustrate with examples close to home. We have been assured that the success of the Air Force program known as “lean logistics” was made possible by AFIT graduates, and not necessarily by the highest ranking ones. Yet, these officers undoubtedly had the same promotion rates as their counterparts with graduate degrees from civilian institutions. Time and time again, we are assured by customers that AFIT graduates do not require a learning curve to speak of, as do their counterparts

from civilian institutions. Also, individuals proclaim publicly that hiring AFIT graduates is the best business practice they know of. Yet, organic graduate education, for better or for worse, stands or falls on the value that its customers and corporate leadership place on five characteristics inherent in organic graduate education: 1) a focused curriculum, 2) relevant research, 3) responsiveness to customer needs, 4) mission-ready graduates, and 5) enhanced assimilation of organizational culture.

Should focused graduate education be the best business practice within the Air Force? To begin to answer this question, we must first discuss the overall requirement for graduate education for the Air Force. As noted previously, the Air Force and DoD are moving into a future defined not only by evolutionary forces but also by a revolution in military affairs; and acquisition reform, “right-sizing,” funding availability, privatization, out-sourcing, lease versus buy decisions, and mission issues will all play roles in this dynamic environment. As discussed earlier, a smaller Air Force will require a force multiplier to achieve its competitive advantage in much the same way as the private sector, and largely for the same reasons—namely, a highly educated technical force structure. In the current downsizing environment, we must be on guard when applying the concept of proportional cuts to education. Under the proportionality argument, since the Air Force has become smaller, the number of advanced academic degree (AAD) requirements should shrink proportionately. This is a specious argument and, in fact, quite the opposite is the case. Just as a higher proportion of the civilian workforce in a high-technology, knowledge-based, and

communications-oriented economy needs focused quality graduate degrees, so do the men and women of tomorrow's Air Force.

This observation applies not just to the select few deemed to be the future leaders who must chart our course, but to personnel at all levels charged with the day-to-day operation of a high-tech, high tempo Air Force, including those who will be acquiring and sustaining its systems. The devil is typically in the implementation, and the individuals who do the actual implementing are found at all levels of the organization. If key people at all levels lack the appropriate education, poor implementation will frustrate the best laid plans (such as decreasing cycle time [Clubb, 1996], or elevating the importance of a bidder's past performance as a source selection criterion) every time.

In today's (and tomorrow's) fast-paced, fluid environment, the Air Force and DoD will need more people with the skills and tools they accrue from a focused graduate education. These include not only the technical and informational skills related to one's major course of study, but the analytical, problem solving, and rational thinking abilities one develops as part of a graduate education. These tools are especially important because they can be applied throughout a career, and to a broad array of problems and situations. Education, after all, is what is left after all the job-specific knowledge and skills are removed. A smaller Air Force needs more advanced, quality technical degrees because it no longer has large numbers of people, inventory, and an abundance of funds to throw at problems. The remaining folks will have to solve unusual and complex problems with brain power. That

is why the Air Force Scientific Advisory Board (AFSAB), in *New World Vistas*, recognized this reality and specifically offered AFIT as an example of a source of Air Force relevant quality graduate technical degrees (AFSAB, 1995). Given the resource-constrained environment, with its manpower reductions and up-tempo implications, the Air Force can no longer afford a square checking exercise in graduate education.

All of us know there are quality civilian institutions, and where "one size fits all," they should be utilized—and they are.^{3,4} But civil-

ian institutions are not interested in certain technologies because they lack large-scale commercial applications. Furthermore, while many of the DoD acquisition orders deal with

primarily commercial goods (commodities, office supplies, etc.) to be sure, other subsets are quite different (combat aircraft, munitions, missiles, etc.). Likewise, some of our acquisition goals and a substantial amount of the DoD acquisition environment (especially the legal aspects) are markedly dissimilar from commercial practices, which are the only ones taught at civilian universities. Finally, the "fog and friction" of combat necessitates a tailor-made logistics system (Pagonis & Cruikshank, 1992). We must face the reality that many pure "just-in-time" logistics systems are severely taxed by the Christmas rush and incapacitated by a

"In today's (and tomorrow's) fast-paced, fluid environment, the Air Force and DoD will need more people with the skills and tools they accrue from a focused graduate education."

United Parcel Service labor stoppage. To quote more fully from *Global Engagement* (1996):

People are at the heart of the Air Force's military capability, and people will continue to be the most important element of the Air Force's success in capitalizing on change. The Air Force of tomorrow and beyond must encourage individuals to be comfortable with uncertainty and willing to make decisions with less than perfect information. Accordingly, our people must understand the doctrine, culture, and competencies of the Air Force as a whole—in addition to mastering their own specialties. Emphasis on creating an Air Force environment that fosters responsiveness and innovation, and rewards adaptability and agility, will be crucial as we move into the early part of the next century.

The qualities and skills cited in the aforementioned quote are needed to create suitable DoD acquisition and logistics systems, processes, and procedures; and they are exactly the attributes provided by the kind of focused graduate degrees offered at AFIT and NPS.

On a broader scale, AFIT's two graduate schools undeniably contribute two of the enabling elements in the force multiplier equation discussed earlier. Certain technologies are of interest principally to the Air Force and the DoD, such as: high-energy lasers, low observable technologies, target recognition, autonomous weapon systems, and unmanned aerial

vehicles. AFIT's School of Engineering offers not only focused curricula in these areas, but also conducts relevant, cutting-edge research on these vital issues. Graduates of these programs are anxious and able to explode out of the starting gate when they arrive at their next assignment.

In the areas of acquisition and logistics, AFIT for years has also provided education and research focused with an Air Force/DoD lens, thereby creating mission-ready graduates. The contributions to management technology include developing improved information resource concepts and systems, and improved management of a weapon system's life cycle, from system acquisition (including acquisition logistics) to operational logistics support.

In addition to the faculty's research streams, over 90 percent of AFIT's thesis research is sponsored by external Air Force and DoD organizations. As noted earlier, this research helps to solve some of the key problems faced by the Air Force as it moves into the next century and produces graduates better able to address additional problems in the future. AFIT's research sponsors have recently estimated that the value of the research they receive is about \$30 million per annum. And fully 80 percent responded that they would have funded this research from other sources had it not been supplied by the AFIT graduate schools.

The Air Force Logistics Management Agency (AFLMA) is the most concentrated locus of AFIT graduates. This assignment permits these young officers to hone analytical skills acquired in graduate school by applying them to some of the most vexing logistics problems facing the Air Force and the DoD. By the time they complete their AFLMA assignment,

these officers are among the most valuable assets that the Air Force possesses.

It is becoming evident that in today's resource-constrained environment, the number one enemy of any military system is cost. Whereas in the past the emphasis was placed on effectiveness, today efficiency is of equal importance. This is particularly true in the field of acquisition, where measures of efficiency such as unit cost and life-cycle cost are key in programmatic decisions. Economy of force, one of the basic principles of warfare, has been cited as one of the justifications for considering different, more efficient, approaches toward acquisition and logistics mission accomplishment (Ely, 1997). The entire concept of cost as an independent variable (CAIV) promotes a push for cost efficiency. But it is management technology that in large measure determines efficiency. In all likelihood, cost pressures will elevate the importance of efficiency as serious attempts are made to balance the federal budget. It will be management technology, focused on the unique aspects and requirements of the Air Force, that determines how successfully this branch of the services executes new initiatives such as acquisition reform, lean logistics, and quality management.

RESPONSIVENESS TO AIR FORCE NEEDS

As the nature of how the Air Force accomplishes its mission changes, requirements for new areas and subjects for Air Force-focused graduate education will appear; and the graduate education process for the Air Force must respond to these new requirements. It will be of paramount importance that these changes be made in a

timely and responsive manner. As organic schools, AFIT and NPS have always considered responsiveness and flexibility to be core competencies.

As an example, the Graduate School of Logistics and Acquisition Management has recently demonstrated responsiveness by implementing a new graduate program that serves as a

prototype for how the changing graduate education needs of the Air Force could be met. This new program, the Master of Air Mo-

bility, was developed for the AMC in conjunction with the Advanced Studies of Air Mobility program at Fort Dix, NJ. The competing requirements for focused graduate education in air mobility, and the need to keep the students involved with the mobility mission, required the use of mixed instructional delivery modes. Many of AFIT's specialized courses are offered on-site at Fort Dix. AFIT instructors fly to Fort Dix to teach courses there on an accelerated basis, while some courses are taught at the AFIT campus and delivered to the Air Mobility Warfare Center through satellite hookup. The AFIT library is connected with the Air Mobility Warfare Center as well. This program was initially requested by the Commander of AMC in September 1994, and implemented in full as an accredited master's program in March 1995.^{2,4}

As an important side note, every student nominated for the first class by AMC already possessed a master's degree in a different discipline. In the future, the re-

"It is becoming evident that in today's resource-constrained environment, the number one enemy of any military system is cost."

duced manning, increased operational tempo, and (for those of us in acquisition) downsized program offices will require that students spend less time in a traditional campus environment than their predecessors did. Educational systems must

"At the moment, looking to best business practices to achieve significant efficiencies within the DoD is the order of the day."

respond to these changing needs by taking education to the student. Clearly, technology will modify the delivery mode of education and

training by making distance learning much more practical and effective than it is today, thereby decreasing the time students spend away from their primary duty. Within the Air Force, AFIT is a leader in pioneering distance learning, and we are actively considering ways to reduce the length of the in-residence portion of our masters degrees.

IN THE FINAL ANALYSIS

Perhaps the ultimate tradeoff to be considered is strictly cost versus value. Any graduate school that produces mission-ready graduates by focusing its curricula and research on customers' needs and by being responsive as part of its mission (consultancy is included in AFIT's mission) will be more expensive. *Ipso facto*, any organization (including the Air Force) would have to pay a premium (or provide a subsidy) to a civilian institution in return for receiving the same responsiveness, attention, and focused education that AFIT currently provides.

AFIT's Board of Visitors determined that the investment the Air Force makes in graduate education at AFIT (\$13.4 million per year) provides an impressive return in terms of mission-ready graduates, as well as focused and responsive research and consultancy. The Board of Visitors report goes on to say: "AFIT provides an array of values that benefit its students, the Air Force and, ultimately, the entire nation." The report concludes with the following remarks: "While there is a premium to be paid to maintain AFIT, the Board of Visitors is unanimous in its belief that there is a richness to the return on investment that cannot be achieved at more traditional civilian educational institutions" ("Report of the AFIT Board of Visitors," 1996).³

At the moment, looking to best business practices to achieve significant efficiencies within the DoD is the order of the day. It would be ironic indeed to abandon focused graduate education at a time when it appears that it is being recognized around the globe by the private sector as the best business practice.

SUMMARY

The acquisition reform initiatives and the Air Force Lightning Bolts are only the beginning—the first chapter in a long saga. To successfully change our acquisition processes to meet our future needs, DoD and the Air Force must produce not only the strategic thinkers in this critical arena who continuously improve existing management technology as well as add to the extant storehouse, but those who are able to implement these "best laid plans."

In an era of ever-shrinking budget authority, the success of force modernization and acquisition reforms will depend on those who can master the complexity and dynamics of the rapidly changing and unique military technological and acquisition environment. Given the differences between civilian and military logistics and acquisition, and the emphasis on efficiency as well as effectiveness, a focused, responsive, and quality graduate education guarantees that the Air Force and the DoD will receive a constant stream of officers and government civilians armed with the strategic mental acuity to solve some of the most vexing problems in the future.

With the disintegration of the Soviet Union, no nation can compete with the United States across the board as far as physical technology is concerned. It is

imperative that such is also the case vis-à-vis management technology, for without it, it is not possible to exploit the full range of physical technologies that a nation possesses. Most would agree that institutions and organizations vested with public interest should be directed by doctrine rather than personality or financial expediency. The evolution of mankind has taken such a path that it is now the size of the brain that constitutes the competitive edge and not the size of the club. But this brain must be honed through appropriate education and training. Now, more than ever, the vital education element of the force multiplier equation must continue to be incorporated as a fundamental tenet of Air Force and DoD doctrine. The consequences of not doing it may very well be unacceptable.

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ENDNOTES

1. Culled from numerous speeches given by the Secretary and Chief of Staff of the Air Force during the first half of 1996.
2. Unlike the Air Force, which is debating the future of the graduate education at AFIT, the U.S. Navy considers the Naval Postgraduate School a “flagship” educational institution, along side the Naval Academy and the Naval War College, to be preserved as a valuable asset.
3. Given the fixed costs associated with launching a new program, before a civilian university would consider such a decision, it would require a guarantee of a sizable number of students for an extended period of time.
4. Typically, it takes two years or more for a new program to be debated and approved by all the curriculum committees, the faculty senate, and for public universities, the Board of Regents or the Department of Education.

OUTLAND: THE VOGUE OF DOD OUTSOURCING AND PRIVATIZATION

J. Michael Brower

The twin silver bullets of outsourcing and privatization are purported to be the saviors of future defense budgets, as private contractors tout their ability to produce goods that retain quality while cutting costs. But this ammunition should be examined carefully before use, for its effects are likely to be devastating to the defense industry's labor force, and estimated savings may evaporate once large segments of the industry are turned over to the private sector.

...Pharaoh commanded the same day the taskmasters of the people, and their officers, saying, Ye shall no more give the people straw to make brick...Go ye, get you straw where you can find it: yet not ought of your work shall be diminished.

Exodus 5:6-7, 11

The Quadrennial Defense Review (QDR) is history—and so too are the hopes of many defense workers for relief from the strains of post-Cold War downsizing. For many, the time of troubles is just beginning. The QDR's report, issued May 19, 1997, called for reductions in infrastructure, support functions, and personnel to fund weapons modernization. But while the study wisely attempts to build more muscle out of the defense budget, in the process it makes some recommendations that have poten-

tially bone-breaking consequences—while leaving some fatty deposits of pork quite untouched. In a well-meaning attempt to put mission first, the QDR forgets that a healthy national defense puts people first always. The QDR's call for unbridled outsourcing and privatization to supplant modernization accounts introduces a sinister game of musical chairs that will put many defense workers off, behind, down, and out.

It will soon be argued that programs receiving the planned financial infusion

will be in a position to employ the tens of thousands of workers to be turned out into the streets under the QDR and concomitant Congressional legislation. But the civilian defense industries are themselves largely saturated and have a general interest only in those with advanced technical skills. Nevertheless, there will be cheap, unionless, competent workers coming soon to an unemployment line near you. The defense workers that remain—uniformed and civil service—will be required to make bricks without straw, to do even more with noticeably less, and they will receive a firsthand education in two rapidly maturing concepts, known as outsourcing and its handmaiden privatization.

HIDDEN ECONOMIC BACKHAND

Outsourcing is the movement of work to an outside provider that has been or might be performed in-house. Privatization is outsourcing writ large—the government farms out the function and often the wherewithal to do it, getting out of a business more logically performed by the private sector. Privatization, in its essentials, is a reaction to the nationalization

and government regulation of the late 1960s and 1970s and finds inspiration in the post-1979 conservative policies of British Prime Minister Margaret Thatcher's government, where the modern privatization mold was cast (Vickers & Yarrow, 1988). But the concept of privatization is not new, and can be traced back to some of Adam Smith's writings in 1762 (Kemp, 1991). To meet the ambitious goals of the QDR, outsourcing and privatization must be relied upon as never before to generate cost savings and cost avoidance to accommodate the proposed modernization schedule (Donnelly, 1996).

With a sort of weary, dull surprise, many who have overseen some outsourcing and to a lesser degree, privatization projects, are discovering that these "new ways of doing business" amount only to old wine in new bottles. Contractors bid for outsourced work claiming substantial savings, government employees are surplusd or RIFed, then (once the indigenous labor source is shuffled off or absorbed) the contractors run up the bill. Uncle Sam then has nowhere else to go, since the in-housers have been benched in the name of savings and efficiencies. It is the charge and duty of the government employee to ensure that taxpayers don't

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get fleeced—but the contractor's first duty is just to charge. For the latter, it is the stockholder, not the taxpayer, that ultimately controls the purse strings. And while many taxpayers are stockholders, as professional Wall Street watchers will tell you, some stockholders are more equal than others.

Privatization and outsourcing are management paradigms that exist because even during downsizing, to paraphrase Calvin Coolidge, the business of America remains business. What Eisenhower called the "military-industrial complex" is an integral part of the U.S. economy and the government. After the Great Depression, World War II, and curative doses of Keynesianism, the government became industry's biggest customer and the two have remained joined at the hip ever since. The Cold War continued and deepened the relationship. Consequently, in the QDR, and in the laws that are passed in legislative reaction, tens of thousands of workers for America's largest employer, the Department of Defense (DoD), will find their fates have been sealed first in American and foreign boardrooms, and only as an afterthought in the halls of Congress and the Pentagon.

Indeed, the reason that the QDR can afford to be so modest in its cuts is more a reflection of a healthy corporate economy that can afford to underwrite \$250 billion Defense budgets for the "foreseeable future" than outright threats to national security. This is why the phrase "security" doesn't receive the emphasis that the phrase "national interests" enjoys in the Pentagon's QDR study—and "national interests," as was the case during the Gulf War, are generally pecuniary in nature. The determination, then, is that the dam-

age done to the economy with the reduced spending power of displaced defense workers and those in their train is more than offset by positive economic effects of industries sanctioned *ipso facto* by the QDR. Cuts in infrastructure (i.e., military installations), personnel, and support functions will be required to ensure the health of large and small corporations alike. Privatization and outsourcing will be the purest expression of the sentiment to support those industries by slashing, among other stakeholders, DoD's indigenous workforce.

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McEMPLOYEE

According to the National Association of Temporary and Staffing Services (NATSS) in Alexandria, VA, outsourcing trends have helped explain increases in the ranks of the nation's temporary employees. Temporary work of all descriptions has doubled in the last five years and in 1995, there were 2.7 million temporary workers in that category.

Additionally, about 40 percent of the biggest companies in the United States have outsourced at least one major piece of their operations, according to *Computer World* (Hoffman, 1997a). DoD is emulating industry and will be outsourcing and privatizing more than ever.

The Navy, for example, is attempting to save more than \$3 billion over the next

six years by designating 50,000 civilian and 30,000 military positions as outsourcing candidates. Fiscal year (FY) 1997 will see the final preparations for outsourcing competitions with the intent of applying the savings toward procurement accounts. In a January 8, 1997, mes-

"The principal problem with the zealous privatizer and outsourcer (a.k.a. 'government reformer') is that they are notoriously short-term thinkers."

sage from Chief of Naval Operations Adm. Jay Johnson, we understand that the "Navy's program objectives memorandum for fiscal year 1998 included...3 bil-

lion in savings from outsourcing," which Johnson terms an "ambitious, but achievable goal" (*Inside the Navy*, 1997). The Navy is continuing to study outsourcing and is countenancing Office of Management and Budget (OMB) Circular 76 ("Performance of Commercial Activities"), which contains competition guidelines updated in early 1996, in anticipation of contracting out more than 10,000 jobs (about 8,400 civilian and 2,300 military) during FY97. The Navy, as of April 1997, had about 408,000 military and 218,000 civilians on its payroll. As the Navy outsources more work it expects to take its \$3 billion in savings and plow it back into modernization programs (*Computer World*, 1997). The problem, of course, is the time delay between banking those savings, and meeting program and operations and maintenance bills.

The principal problem with the zealous privatizer and outsourcer (a.k.a. "government reformer") is that they are notoriously short-term thinkers. They forget or

never bother to calculate the stimulation that government paychecks have in the economy. In the private sector, a firm can hire more workers when demand is high, lay them off during a lull in demand—but this is not so in government. The axiom that layoffs boost profits in the short term is verifiable (and is in part accountable for the historic rise of the U.S. stock market), but long-term effects may be less desirable.

A related development, which is gaining momentum and adherents, is the "franchising" or hiring of temporary government workers, who are then terminated at project completion. Headlines in recent months about "payoffs for layoffs," an issue championed by independent Vermont Rep. Bernie Sanders, and the introduction of legislation such as the "freedom from government competition" bill, all center on the continuing destruction of good, tax-base creating jobs in the public and private sector. Today's "government reformer" is in many cases using privatization and outsourcing as cudgels to beat down concepts that working Americans did not always associate with sloth: steady employment, good fringe benefits, security, decent working hours and conditions, paid vacation and sick time, health care, a well-funded retirement. But to be progressive today, one cannot support these notions. The popular belief in this country (unlike in Japan and Germany) seems to be that those working in government today must by definition be deficient—they obviously couldn't make it in private industry. Ridiculous as the prejudice is, these concepts are spreading according to critically acclaimed books such as Jeremy Rifkin's *The End of Work* (1995) and William Greider's *One World Ready or Not*:

The Manic Logic of Global Capitalism (1997). Both authors assert that privatization and outsourcing will continue apace, no matter the economic or social cost.

NEW STRAINS OF OUTSOURCING

A review of outsourcing and privatization literature reveals fewer references to fixed costs, rates of rent or taxes, or the price of capital and materials than to the cost of labor. In the main, the cost cuts that outsourcing achieves are accomplished by reducing the price of the employee. By capitalizing on the specialization of techniques, specific functions done at low cost can trim a company's on-site workforce. Two new genres of outsourcing highlight this interest in reducing people-generated expenses.

PURE OUTSOURCING

Here we find a new social contract at work—but Locke didn't have this one in mind. Private industry is permitted to purchase, at a discount, publicly underwritten facilities and acquire trained employees with the understanding the taxpayer will end up with a better deal. This is the same pretext rationalizing the privatization of the U.S. uranium enrichment business (Moses, 1997). In an ode to outsourcing, *National Defense's* December 1996 issue states the case plainly enough. Sandra I. Meadows introduces "pure outsourcing" (and it does have a pleasant, almost religious ring to it). The new addition to the lexicon of privatizers and outsourcers is a scheme to transfer all government workers and all government assets in a given field into the waiting hands of a company.

Addressing the popular inclination to outsource information systems, "a government data center would transfer its assets and employees to a private firm, which would be running the operation—becoming an agency partner rather than just a supplier." Later she writes, "there is mounting pressure on corporations, both in the public and private sector, to be more efficient, to perform new functions with fewer employees" (Meadows, 1996).

With "pure outsourcing" the public underwrites the private sector by virtually or literally giving away taxpayer-purchased facilities and assets, cuts government's employee costs by transferring workers to industry, and saturates the labor pool. As wages fall, the regular paychecks on which workers depend to underwrite their bills become more exception than rule.

DOUBLE OUTSOURCING

Also known as "mad cow contracting-out," double outsourcing is one of the most hazardous breeds of the outsourcing animal. Simply put, it means subcontracting to the *n*th power—triple or even quadruple outsourcing—and it is daily becoming more the rule than the exception. For instance, the EDS Company supplied information technology requirements for Gen-

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eral Motors Corporation for more than 12 years. Then GM negotiated a \$3.6 billion deal to co-negotiate with EDS ("double outsource") with EDS's subcontractors (*Information Week*, 1997). Economies of scale are realized by pooling resources and labor costs are driven to lower levels. For example, Microsoft has a rather modest employee base compared to its revenue, due in part to an aggressive outsourcing strategy, which can involve double-outsourcing, particularly in the code writing arena. But outsourcing can lead to severe labor problems: the machinist strike at McDonnell Douglas, which started in June 1996, was largely fought over the question of outsourcing to nonunion sub-contracts.

Other forms of outsourcing run the gamut between the straight GOGO (government-owned, government-operated) model and the COCO (contractor-owned, contractor-operated) model. These forms include co-sourcing (partnering equipment and expertise with an outsider), and outsourcing partnerships (generally, only the technical staff is outsourced).

Outsourcing also finds many labor cost savings in the area of information tech-

"Typically, the outsourcer bids low, gets exclusive rights to control an entire information technology department, then reams the outsourcee with cost overruns."

nology, and QDR's suggestion that DoD largely remove itself from that line of work has many precedents in private industry and in other parts of government.

The Internal Revenue Service is outsourcing returns processing, while the Academy of Motion Picture Arts and Sci-

ences is relying on outsourcing services rather than "overburden[ing] its small Management Information Systems (MIS) department." Brian Riggs reports in his piece "Web Outsourcing Hits Big Time," that installing and operating a Web server can cost above \$60,000 a year—and two full-time computer jockeys added on boost the price to \$221,000 (Riggs, 1997). But outsourcing such a project lowers costs to about \$40,000. But according to *Computer World*, the outsourcing Siren song has run many companies into the ground (Melymuka, 1997). Typically, the outsourcer bids low, gets exclusive rights to control an entire information technology department, then reams the outsourcee with cost overruns.

WHO REALLY WANTS OUTSOURCING AND PRIVATIZATION?

At the Pentagon, one notices that those above the rank of colonel and GS-14 and political appointees are almost wholly in favor of outsourcing and privatization. For the political appointee with a limited future in government, job security is job none anyway, so why worry about the fate of middle and lower income taxpayers working for DoD? For the high grades, there is no danger of them becoming victims of privatization, outsourcing or "re-invention" in general—quite the reverse! Mike Causey's popular federal column in the *Washington Post* (1997) featured a Dickensian commentary on the haves having and the have-nots having nothing. Causey estimates that between 1989 and March 1995, the number of GS-14s and -15s soared during downsizing (14s went from 69,000 to 83,000; more than 7,000

new 15s were created). In the same moment, those in grades below GS-7 have found themselves in a free-you're-fired zone. Since "government reinvention," began, GS-1s have been virtually eliminated, GS-2s lost nearly 6,000 positions, GS-4s were cut in half, and GS-7s were reduced by 30,000 positions.

On both the military and civilian side of DoD, we see a pattern common with most downsizing, the Personnel Centripetal Effect: headquarter staffs swell while the field shrivels. To preserve the upper grades, work done by the lower tier is contracted out (hence the worship of outsourcing, economical or not) and numbers of employees are shown to decline. The problem is that those who can least afford to go—the young, the low grades, the "temps"—are forced out, while those who can easily afford departure remain. Voluntary retirements and incentives have helped, but the QDR demands more cuts and Congress is asking for still deeper position reductions.

The military remains hopelessly top heavy. A few years ago, the Air Force actually had to eliminate the basic rank of "sergeant" and RIF many junior officers, mainly to preserve positions in the service's stratosphere. In the QDR, forces were cut, but force structure was preserved. Truly, as the African proverb has it, when elephants fight, the grass suffers.

In a sinister twist, there is now a big push to get people "off welfare" by putting many of them into the government in the same low-grade categories that were sacrificed on the alter of reinvention. Private industry only employs up to the point of diminishing returns: when employees cost more than they return to the company in profits, they become economic liabilities;

their utility is at an end. The unthinkable but perfectly practical solution would have been to simply lower the grades of the upper-level military and civil servants to better reflect a post-Cold War world, and use the savings to avoid cutting jobs. Yet no economic analysis of this possibility was conducted, because

of the anticipated conduct of the fox when stationed at the hen house. In this ironic form of social leveling, many of those RIFed might now be reemployed by the government

that released them from service (and don't forget about veteran's preference and reinstatement rules).

Take another example of who gets what from the outsourcing phenomenon. The Defense Science Board's (DSB's) estimates of outsourcing and privatization savings to DoD of \$30 billion per year by 2002 were disputed by officials in the Office of the Secretary of Defense's (OSD) program analysis and evaluation (PA&E) shop. In early April, PA&E's examination of the much-heralded DSB summer study, "Achieving an Innovative Support Structure for 21st Century Military Superiority," indicated that even after aggressive contracting out, there could be less than \$14.8 billion in savings opportunities. Even that figure would depend on repeal of restrictive legislation, higher than anticipated personnel cuts, and more base realignment and closure (BRAC) proceed-

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ings. Why are the estimates so different by so many billions?

There are (at least) two possible explanations for the discrepancies. The OSD PA&E may estimate conservatively because it has vested interests in doing so—just as the members of the DSB have

"In the last analysis, the relative and socially necessary labor price makes or breaks most privatization and outsourcing initiatives."

vested interests in liberal estimates in the amount to be saved through outsourcing and privatization. OSD PA&E would see more substantial sav-

ings estimates gobbled up to fund other programs (the higher the estimate of savings, the greater the cuts somewhere else). Another reason for the disparity could be that the DSB generally consists of a membership that can be less than objective. In the course of examining the PA&E analysis, "most reviews are performed by people who have a stake in the process" (*Inside the Air Force*, 1997).

PAYING THE PRICE, NOT COUNTING THE COST

To be sure, there have been economical privatizations and outsourcings. State and local governments have in many instances reported success, especially when results were measured using an activity-based costing (ABC) approach. In a March 1997 privatization study conducted by the General Accounting Office (GAO), an interesting discovery was made about the role played by the price of labor in privatization projects. When laws were en-

acted that required private firms to "compensate [former government employees] at a rate comparable to their government pay and benefits," privatizations dramatically declined.

In the last analysis, the relative and socially necessary labor price makes or breaks most privatization and outsourcing initiatives. Each case, therefore, must be handled individually, since privatization and outsourcing have experienced some profound failures and false starts, and usually entail traumatic work force transition (GAO, 1997, p. 4). For instance, in a major outsourcing flop for Unisys Corporation, unanticipated "labor-intensiveness" caused an early termination of a contract to manage the health-care program for the state of Florida's 215,000 employees. The contract was worth \$86 million over four years and, with labor savings being again the financial incentive for the outsourcing venture ("we can do it better, cheaper"), a Unisys spokesman admitted that the contract was "an aberration, an aggressive move" and one that proved a bridge too far (Caldwell, 1997).

In the case of unregulated privatization, the long-term problems of destroying government as a steward of a nation's resources can be best illustrated in Russia. As Gary Bertsch and Igor Khripunov pointed out in their article "Privatization Carries Cost" (1996), the "largest proliferation of weapons and weapon-related technology in human history" is beginning to take place because the recently privatized high-tech Russian companies have no "nonproliferation culture." Nor has there been time or opportunity to build such a culture (which would have had to overcome the impetus of history), given that Russia's private sector is "locked in a

merciless struggle for survival”(Bertsch & Khripunov, 1996). Privatization has driven the former Soviet Union and its former East European comrades into a new competition with America for the title of leading arms seller and producer. The ideological struggle may have subsided, but the economic struggle continues.

START THE REVOLUTION IN BUSINESS AFFAIRS WITHOUT ME!

Outsourcing and privatization, if considered on a case-by-case basis and taken in moderation, can be beneficial. It is definitely here to stay, or, if we forget our duty to our fellow workers, here to slay. American companies out-source more than \$100 billion a year, with average cost savings of 10–15 percent; the federal government spent about \$114 billion on outsourcing during 1995 but lacked the mechanisms (e.g., activity-based costing models) for calculating savings (Lowry, 1996). But optimism springs eternal: Texas Gov. George W. Bush, son of the former president, believes he can save the state 40 percent of current computer costs (as much as \$120 million) by outsourcing welfare information systems work (Hoffman, 1997b). But massive job slashings that give people no place to turn, dispensed willy-nilly, can create economic and social chaos.

The so-called Revolution in Business Affairs (which is the complement of the technology-based Revolution in Military Affairs) was initially launched to help Defense workers conduct the Department's affairs more economically and effectively—not give them the business. Defense workers are just regular people: they carry debt, pay their rents and mortgages,

support children through school. If DoD workers are something other than “economically viable,” then we need to explore ways to make them so. But neither national security nor “national interests” are served by arbitrarily putting huge numbers of them on the cold side of the employer's door where there are no jobs commensurate with their old paychecks and abilities. The problem with out-of-work Russian nuclear specialists and frustrated, unemployed Eastern European mathematicians who can earn more as authors of computer viruses than of textbooks should not be lessons lost on us.

The noted conservative commentator Henry Hazlitt reminded us in his classic work *Economics In One Lesson* (1946), that “in studying the effects of any given economic proposal we must trace not merely the immediate results

“If DoD workers are something other than “economically viable,” then we need to explore ways to make them so.”

but the results in the long run, not merely the primary consequences but the secondary consequences, and not merely the effects on some special group but the effects on everyone.” Not so readily examined by the “reformers” seeking the Red Badge of Downsizing is the aftermath of transforming reasonably paid Defense workers (motto: “Together, we can build it”) into pauperized McEmployees (motto: “Would there be fries with that?”). If DoD is about people always, privatization and outsourcing must be outfitted with a human face, or a higher economic and social price will be paid by all, not far enough down the line.

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CHANGING THE WAY WE ASSESS LEADERSHIP

Mary-jo Hall, Ph.D.

Defense leaders face unprecedented challenges of accelerating change in a world without a Cold War. The technology explosion is forcing reduced cycle times as acquisition leaders lead the way to "better, faster, and cheaper." Specific initiatives and reforms such as single process initiative, electrical combat/electronic data interchange (EC/EDI), cost as an independent variable, and increased emphasis on commercial specifications helped accomplish this. The challenges, however, will not go away. The acquisition community cannot meet these demands simply by implementing the reform efforts of the Colleen Preston (former Deputy Under Secretary of Defense [Acquisition Reform]) era. To ensure that cost, schedule, and performance are continually improved, change must be inextricably linked to both the "thinking" and the "doing" of the T.S. Eliot quote below. Change is required at the organizational level, the team level, and the personal level, so the acquisition community can operate effectively and efficiently within a constrained budget and with fewer people. To effect this transformation, leaders must lead differently. Einstein's insight reflects this imperative: "No problem can be solved from the same consciousness that created it; we must learn to see the world anew." Continuing to do what we have always done will only get us what we already have. Better, faster, and cheaper weapons systems, flexible management systems, and empowered integrated product teams are required to produce new results.

...between the thinking and the doing lies the shadow.
—T. S. Eliot

To operate productively in an environment of constant change, leaders must think and act differently. Change efforts, such as the acquisition reform initiatives, must be considered part of a transformation process, not an "event" to be managed. Leaders who are effective

in the change wave must be visionary, apply a systems approach to their problem solving, encourage out-of-the-box thinking, appreciate the dynamics of teams, know the reality of change management, and operate effectively in a chaotic world. The capacity to lead in this

scenario requires the skills to establish direction; align people, systems, and resources; and motivate and inspire followers (Kotter, 1996a). Leaders must continually learn and enhance their management techniques to encourage excellent performance in a complex environment. To do this leaders must lead the change process. They must adapt to change while remaining focused on the strategic direction. Peter Vaill, in *Learning as a Way of Being* (1996a), calls this approach to continual, real-time change “leaderly learning.”

The purpose of this article is twofold. The first is to present a theory of leadership for the circumstances described above. The second is to provide managers with a method for assessing their present capability and building personal mastery associated with the theory. So first I will present a theory focusing on leadership in a world of accelerating change. It provides definitions for leadership in terms of the dimensions that research indicates are necessary for leading in a volatile, uncertain, ambiguous world where the only constant is faster change. Then I will provide a practical, hands-on tutorial for self-directed, intentional learning to increase capacity for the type of leadership detailed in the theoretical model. The framework includes techniques for assessing present leadership capacity, a tool for describing and demonstrating this capacity, and a model for intentional learning to increase capacity. The framework helps

eliminate the “shadow” in Eliot’s quote by presenting tools for “doing.”

LEADERSHIP AS LEARNING

My research for assessing personal leadership capacity began several years ago in my role as organizational change catalyst. During 1994, I researched and benchmarked best practices. I formalized findings and concepts into a paper that was subsequently presented at the American Association of Higher Education Conference in June 1996, and at the University of Maryland Symposium, Leaders and Change, in September 1996 (Hall, 1996). The two meetings led me to rethink the leadership content presented in the original paper. Based on further research, especially the influence of Peter Vaill and John Kotter (who has written extensively on leading change), I revised the leadership content.

As expressed by Kotter (1990, 1996a) there is a critical distinction between leadership and management. He states that “Management is a set of processes [planning, budgeting, organizing, staffing, problem-solving, etc.] that keep a system...running” (1996, p. 25). Leadership, on the other hand, is defining the future, aligning the people (and all of the systems and resources) with that particular future and then inspiring people to create that future. See Appendix A for

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Kotter's distinction between management and leadership.

While both management and leadership are necessary, the change and complexity associated with the future demands that the leadership role takes precedence over the management role. This concept of managerial leadership in an environment full of surprising, novel, messy events demanding attention is described as "permanent white water" (Vaill, 1989).

Leading in this environment implies learning new ways of operating and behaving based on the demands and reality of a changing context. As Farkas and Wetlaufer wrote in the *Harvard Business Review* (1996), "CEOs must learn on the job how to lead a company, and they must learn while every stockholder is watching." Dixon (1996, p. 4) references Robert Kegan's work, *In Over Our Head*, and states: "People find themselves in over their heads much of the time. The organizations in which people work are also in over their heads. They are actively searching for new ways of acting and interacting."

Change is not only a phenomenon associated with organizations desiring to be more customer-driven, more team oriented, and more inclined to make decisions based on data. Change is pervasive in all facets of our present and future world, from demographics, to technology, to global issues. Living in the present and future world successfully requires extraordinary changes in knowledge, skills, attitudes, and behaviors. Gaining this new capacity requires a focused, conscious awareness of the learning process and a dedication to improve intentional, personal learning through planning and self-direction.

To develop self-planned, intentional learning, individuals need to understand the purpose for learning (the why of learning), have strategies, methods, and resources for learning (the how of learning), and they need to be able to comprehend the content (the what of learning). They need to have the skills to assess present capacity and establish specific objectives to enable future learning. The opportunity for human learning occurs every day. However, for learning to translate into new skills, behaviors, and competencies on the job, learning must be purposeful, directed, and intentional.

The original version of this work presents the primary skills of leaders of change as: focus (vision, strategic goals, purpose), direction (values, communication, stretch goals, a customer focus, using data to drive decisions), guidance (process improvement, use of tools, teaming continual improvements), and support (consistency in support systems, encouraging innovation, etc.). The revised version provides five dimensions for leadership; the major differences being primarily in the emphasis on personal learning and managing change.

Here I describe the dimensions of leadership as: personal learning; establishing direction; aligning people, systems, and resources; motivating and inspiring followers; and managing change. The revised leadership context takes into account the

"While both management and leadership are necessary, the change and complexity associated with the future demands that the leadership role takes precedence over the management role."

complexity inherent in present and future leadership, especially in the face of the “permanent white water” characteristic of acquisition reform.

PERSONAL LEARNING

The problem with real-time, self-directed learning for leaders is that it is assumed that leaders know more than others. Today the rate, volume, and variety of change is increasing at such a rate that leaders are in a constant state of learning—they do not have the luxury of prior experience and knowledge. Vaill calls this “leading a learning process” (1996b, p. 2). He goes on to postulate a learning premise (1996b, p. 8).

In dynamic, rapidly changing situations of “permanent white water,” where unprecedented challenges and crisis are occurring continually, the ability to learn effectively is the primary (in)competence. Therefore, effective managerial leadership in such situations cannot ever be sufficiently learned.

Effective managerial leadership in such situations is learning.

The premise is profound in that it recognizes that the purpose of education is not to teach the present reality, but rather, to create an environment where everyone is enabled to learn about their learning and to learn methods, strategies, and tools to improve their unique learning process. The question Vaill puts forth is: “To what extent are the individuals who are in posi-

tions of leadership...focusing (and being helped to focus) on their own learning abilities on the subject of leadership?” (1996b, p. 9). Thus, leadership is about learning. Vaill (1996b) posits that reflection is an integral aspect of this process and that a reflective learner “...learns about ourselves as learners...” (p. 84). He further adds that the reflective learning system relies on self direction, creativity, expressiveness, feeling the meaning, learning on-line, and continuous learning.

The self-directed mode of learning is the degree to which intentional learning is guided by personal choice, not dependence on others. “In reflexive activities we are trying to understand how to increase our personal sense of ownership in our learning” (Vaill, 1996a, p. 87). Creative learning implies that we are going into unexplored territory, not just doing what others have done before. Expressive learning is being engaged actively, not merely absorbing. Feeling learning is knowing the gut reaction to the learning. It is the emotional element that engages the brain to an extent not possible without emotion. On-line learning broadens our learning because we are consciously and intentionally learning new subjects, new topics, and exploring areas. This implies a willingness and openness to learn about a variety of options rather than sticking to the known. This means experiential learning, not passive listening. Continual learning implies continual intentional learning, i.e., by design and consciousness, not ad hoc and by osmosis.

Learning can be part of every work process. When it is, it continually stretches the people involved in the learning and expands the capability of the organization. Peter Senge states (1990, p. 14):

Real learning gets to the heart of what it means to be human. Through learning we re-create ourselves. Through learning we become able to do something we never were able to do. Through learning, we re-perceive the world and our relationship to it. Through learning we extend our capacity to create, to be part of the generative process of life.

ESTABLISHING DIRECTION

Establishing direction implies a clear vision for the future and strategies to get to the vision. The purpose for establishing direction is to transform the organization into something different than its present state. The purpose is not to have detailed plans that occupy shelf space and are posted on the World Wide Web. For the acquisition community, establishing direction implies a business approach with the tenets of the Government Performance and Results Act and Acquisition Reform inherent in every aspect of the operation. The primary skills needed by leaders to establish direction are creating a vision and articulating that vision to the extent that the organizational leadership is able to develop strategies to realize the vision (Kotter, 1990). This vision is a clear picture of a future state that looks at the organization as a whole, integrated system, not a group of individual parts or vertical stovepipes. Setting and communicating a clear picture of the future focuses on outcomes that are consistent with the requirements of present and future customers. Progress toward the vision is measured periodically with performance results.

Leading in this manner promotes innovation by everyone and models integrity through open communication consistent with behavior, the cornerstone of a high-performance, agile organization.

ALIGNING PEOPLE, SYSTEMS, AND RESOURCES

Aligning people with vision and strategies is easier said than done. It requires extensive communication in a variety of formats (e.g., verbal, written, electronic, personal). It also requires "buy-in" from everyone for the vision and commitment to its achievement and success. This implies two-way communication. Listening is most important in creating an environment in which all are enabled to empower themselves. Asking pertinent and thought-provoking questions about the system is as important as providing solutions. Communication is not just verbal and written, it includes modeling core values of the organization such as teaming, trust, empowerment, and excellence. Communication builds trust within and among all people by actions that match words, thus instilling integrity in the system.

While Kotter focuses primarily on aligning people, research also indicates that systems and resources must be aligned with the vision and the strategies as a precursor for involvement and commitment. For example, if reward and recognition

"Establishing direction implies a clear vision for the future and strategies to get to the vision."

systems do not support the vision, values, and strategies, it is difficult to inspire and motivate people to continually improve and change.

MOTIVATING AND INSPIRING FOLLOWERS

Motivating and inspiring others is necessary to keep the change journey on track and progressing. Kotter states (1990, p. 61):

...direction setting identifies an appropriate path for movement, effective alignment gets people moving down that path, and a successful motivational effort assures that those people will have the energy to overcome obstacles in their way.

The change journey has barriers, obstacles, challenges, and hurdles that continually surface. Being able to stay focused on the vision and strategies when these barriers surface is like changing a tire

"Motivating and inspiring others is necessary to keep the change journey on track and progressing."

while the car is zooming down the interstate at 60 mph. Inspiring and motivating others involves accepting people for their unique contributions, supporting innovation and risk taking, and being constantly self-motivated. It is inherent that the diversity of the workforce in terms of race, gender, learning style, personality type, functional specialty, service, grade, and rank, influences the efficacy and pro-

ductivity of integrated product teams. However, for the impact to be positive, the leader must motivate and inspire all team members, not just a few.

MANAGING CHANGE

Managers must lead to the vision through unprecedented challenges and change; therefore, the effective leader must manage the change as a never-ending process, not as a specific event or activity. While it behooves leaders to focus on the present change, it is more important that leaders understand and work with others on the process of continual change. The capacity to manage change is best summarized by Kotter (1996a) and includes: establishing a sense of urgency, creating the guiding coalition, developing a vision and strategy, communicating the change vision, empowering broad-based action, generating short-term wins, consolidating gains, and producing more change and anchoring new approaches in the culture (see Appendix B for further breakdown).

While some of the skills, competencies, and behaviors needed to lead a focused change process are the same general skills, competencies, and behaviors needed by leaders in a more stable environment (for example, establishing direction), Kotter's managing change category is purposefully presented intact because of the thoroughness and acceptability of the model. Additionally, this model is compatible with the classic three-step procedure of change model (unfreezing, movement, and re-freezing) presented by Kurt Lewin (1951). Kotter's (1996b, p. 59) research documents that not doing any one of the ac-

tions results in a change effort that is not as successful as expected: "...the change process goes through a series of phases that, in total, usually require a considerable length of time. Skipping steps creates only the illusion of speed and never produces a satisfying result."

ASSESSMENT USING A CAPACITY MATRIX

Identifying the competencies, the skills, and the behaviors to lead organizational change is the first step in the learning process. The individual's capacity in each of the five leadership dimensions areas must then be assessed to determine present capacity. Goals and a plan to reach the goals must then be developed. To get results and build capacity, the plan must be implemented and assessed. This article uses David Langford's "capacity matrix" as the tool (Appendix C) to assess personal capacity to lead change in a volatile world (1995). The competencies, behaviors, and skills from the five leadership dimensions are loaded into the tool.

According to Langford, the capacity matrix gives responsibility for both evaluation and learning to the individual. In the matrix the horizontal axis depicts the skills, competencies, and behaviors identified as the five dimensions of leadership. The vertical axis shows the learning levels broken down by a variation of Bloom's Learning Taxonomy, developed by Langford and Myron Tribus (Langford, 1995). These categories are knowledge, know-how, and wisdom.

As described by Langford (1995), *knowledge* includes obtaining information and the ability to recall it, especially at the appropriate time (for example, re-

sponding to test questions about a topic). Knowledge can be demonstrated by: naming, listing, defining, and answering: who, what, where, when, how many, and how much?

Know-how is the ability to understand or comprehend and apply knowledge and to analyze information. Comprehension can be demonstrated by: giving examples; telling what probably will happen; telling what caused an incident; comparing; contrasting; presenting an idea in your own words; and using terminology associated with the concept in a meaningful way.

Application is the ability to use ideas, concepts, methods, and principles in new situations. The process of applying a skill or competence is demonstrated by solving challenges, generalizing from one situation to another, and probing for answers.

Analysis is methodically examining ideas and concepts and separating them into parts or basic principles. Analysis requires knowledge, comprehension, and application. In the Langford/Tribus model, the *wisdom* category includes judgment (discerning), synthesis (creating), and appreciation or evaluation. Judgment includes comparing, assessing, reflecting, observing, thinking, correlating, and focusing.

Synthesis is the ability to put together parts and elements into a unified whole, which requires original and creative thinking. It includes constructing a model, creating a plan, or arranging pieces together that probably were not previously joined.

"Identifying the competencies, the skills, and the behaviors to lead organizational change is the first step in the learning process."

Appreciation is the ability to acknowledge or judge the value of ideas, procedures, and methods using appropriate criteria, such as usefulness or effectiveness. It is the ability to predict, measure, and select. It also includes substantiating with facts, theories, and observations.

The capacity matrix, using these levels of learning, is a living document that is regularly updated by the learner. Shading, color-coding or other indicators are used to assess personal capacity in a particular skill, competency, or behavior.

DOCUMENTATION USING A PORTFOLIO

Self assessment of one's individual capacity to lead change using the capacity matrix is a start. But as W. Edwards Deming (1993) frequently asked, "How

do you know your assessment is accurate?" Personal learning implies actually learning how to learn and continually improving that process. Learning happens in a variety of ways. It can be through experience, modeling, and inputs such as lectures, videos, and texts (Langford, 1995, a-11). Part of the personal change process is understanding the effectiveness of the different ways one personally learns.

One's measure of personal learning is a portfolio documenting, defending, and describing present capacity. This portfolio can be a handwritten notebook with tabs for each of the skills, behaviors, and competencies, or it can be electronic with hyperlink text and multimedia portions.

Documentation includes storyboards from projects, feedback from others, reports, videos of presentations, or personal documentation of the learning process (for example, a learning journal that substantiates the assessment level on the capacity matrix). The capacity portfolio documents what you presently know with examples and answers the questions "How do I know I know, and at what level or competency?"

The portfolio also reflects documentation of what others think about your capacity level as well as what you think. One strategy for determining what others think is customer feedback. Mechanisms for receiving feedback include climate surveys of the organization such as the Campbell Organizational Survey, feedback from work processes, letters, certificates, and Multirater Assessment (360° Feedback). The importance of a "reality check" by soliciting data from a variety of sources cannot be overemphasized.

INTENTIONAL LEARNING

Having completed an assessment of your capacity as a leader of change, documented and described your skills, knowledge, and activities in a portfolio, how do you continue intentional, self-directed learning? A model developed by Wick and Leon (1993) and used extensively by industry, is called SMART learning (select, map, act, review, and target). A modification of this model includes the following steps:

Step 1 is to select a goal based on present and future importance to the organization. Identifying one goal at the time and working on that particular goal for approximately 4 months is the recom-

mended strategy. Selection of a goal is based on both the gaps in the capacity matrix and personal analysis.

Step 2 is to map out achievement of the goal with a detailed learning map. Concentrate on the purpose and the results simultaneously. Incorporate planning and management tools to quantify as much of the plan as possible. A suggested format for the map includes:

- a learning goal;
- action steps with milestone chart (be specific and detailed);
- resources needed (this could be a matrix of people, materials, and resources);
- barriers anticipated (force field analysis);
- measurement of result (from capacity matrix levels);
- future organization benefits;
- future personal benefits; and
- a planned completion date.

Step 3 is to act on the plan. Determine progress on a monthly basis. Analyze both the content and the process of the learning. Make mid-course corrections in the plan. Recommendations to help stay on track include using learning partners/mentors, visual reminders adaptable to particular calendars or daytimers and learning journals for reflection, lessons learned, idea development, and linking new information with present knowledge.

Step 4 is to review and evaluate learning and the learning process. Continually reflecting on the learning process is important to make connections with other learning and to transfer the new learning to on-the-job practice. Reflecting and questioning tacit assumptions helps define and clarify one's belief system. Using the new learning is imperative; thus finding practice opportunities is a constant need.

"Reflecting and questioning tacit assumptions helps define and clarify one's belief system."

Step 5 is to target the next learning goal. This implies going back to the learning purpose and the capacity matrix. This phase in the learning triggers a new learning cycle and repeating the assessment, documentation, planning, and learning sequence. This cycle for building personal capacity increases leadership skills and promotes higher levels of learning. It models leaderly learning.

SUMMARY

The bottom line in assessing personal leadership effectiveness is improving personal capacity to lead in the complex, changing world of permanent white water, regardless of the present acquisition reform initiative. This implies improving your skills, competencies, and behaviors through intentional, self-directed, personal learning, and it includes having the skills to establish direction for a work group, team, or organization. This leadership skill also assumes having the capacity to align people, systems, and resources toward a

common vision; motivate and inspire all members; and successfully manage change. The assessment, documentation, and planning for learning are simply activities if the results do not improve leadership and contribute to acquisition systems that meet the requirements of the warfighters.

Commitment to improve one's personal capacity to lead is generally based on intrinsic motivation. It is, however, the primary role of the leader of change. It is impossible for leaders to build a team or an organization into something different from themselves (Clemmer, 1995). For leaders to expect the organization to change, they must understand the change process and how people react to change. For leaders to expect the organization to improve, they must improve themselves using a disciplined approach. For leaders to expect everyone to contribute to the vision and mission, they must personally

contribute to the vision and mission. For an organization to move toward its vision, all systems must be aligned and individuals must be intrinsically motivated and inspired.

The greatest loss in any organization is the inability to tap the full measure of human potential. The leadership role in today's organizations places great emphasis on transforming the enterprise through others. Leaders need to engage 100 percent of their members in producing outcomes required by customers. In the acquisition community this means weapon systems for warfighters that meet cost, schedule, and performance requirements in a downsized, budget-constrained environment. To meet this challenge, leaders must model self-directed, intentional, real-time learning. They then will eliminate the shadow between thinking and doing in personally mastering leaderly learning.

The statements of fact or opinion appearing in this document are solely attributable to the authors and are not necessarily endorsed by the Department of Defense or the Defense Acquisition University.

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APPENDIX A

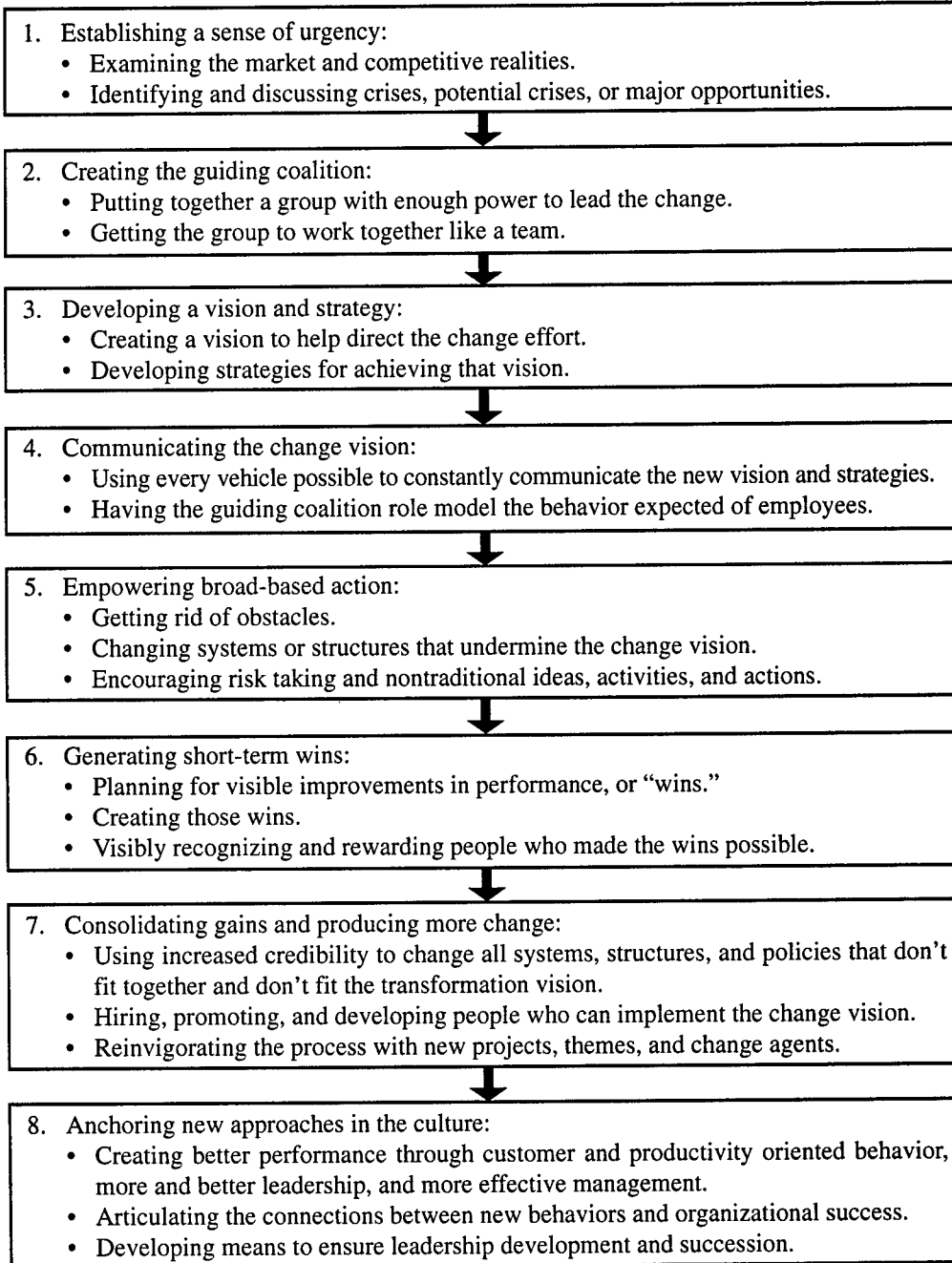
KOTTER'S COMPARISON OF MANAGEMENT AND LEADERSHIP

	Management	Leadership
Creating an agenda	Planning and budgeting: Establishing detailed steps and timetables for achieving needed results, and then allocating the resources necessary to make that happen.	Establishing direction: Developing a vision of the future, often the distant future, and devising strategies for producing the changes needed to achieve that vision.
Developing a human network for achieving the agenda	Organizing and staffing: Establishing some structure for accomplishing plan requirements staffing that structure with individuals, delegating responsibility and authority for carrying out the plan, providing policies and procedures to help guide people and creating methods or systems to monitor implementation.	Aligning people: Communicating the direction by words and deeds to all those whose cooperation may be needed so as to influence the creation of teams and coalitions that understand the vision and strategies, and accept their validity.
Execution	Controlling and problem solving: Monitoring results versus plan in some detail, identifying deviations, and then planning and organizing to solve these problems.	Motivating and inspiring: Energizing people to overcome major political, bureaucratic, and resource barriers to change by satisfying very basic, but often unfulfilled, human needs.
Outcomes	Produces a degree of predictability and order, and has the potential to consistently produce key results expected by various stakeholders (e.g., for customers, always being on time; for stockholders, being on budget).	Produces change, often to a dramatic degree, and has the potential to produce extremely useful change (e.g., new products that customers want, new approaches to labor relations that help make a firm more competitive).

Source: Taken from Kotter, J. P. (1990). *A Force for Change*. New York: The Free Press.

APPENDIX B

THE EIGHT-STAGE PROCESS OF CREATING MAJOR CHANGE



Source: Taken from Kotter, J. P. (1995, March–April). *Harvard Business Review*.

APPENDIX C

TABLE 1. CAPACITY MATRIX FOR INCREASING PERSONAL LEADERSHIP CAPACITY

Outcome	Competencies	Breakdown	Knowledge	Know-how	Wisdom
Leadership for change	Personal learning	Learning process			
		Individual learning			
		Team learning			
		Organizational learning			
		Reflection/reflectivity			
		Self direction			
		Creativity			
		Expressiveness			
		Feeling the meaning			
		Learning on-line			
		Continuous learning			

Source: Text taken from Vaill, P. (1996). *Leadership Is Not Learned: It Is Learning*, Proceeding of the 1996 NLI Conference: Leaders and Change.

APPENDIX C

TABLE 2. CAPACITY MATRIX FOR INCREASING PERSONAL LEADERSHIP CAPACITY

Outcome	Competencies	Breakdown	Knowledge	Know-how	Wisdom
Leadership for change	Establishing direction	Creating a vision			
		Thinking from a systems perspective			
		Developing strategies			
		Focusing on outcomes			
		Assessing performance			
		Defining priorities			
		Clarify roles			
		Modeling integrity			
		Understanding stakeholder requirements			
		Analyzing feasibility of strategies			
		Promoting innovation			

Source: Text taken from Hall, M. (1996). *Proceedings: The 1996 NTL Conference: Leaders and Change*. "Increasing Leadership Capacity to Transform Organizations" College Park, MD: The University of Maryland.

APPENDIX C

TABLE 3. CAPACITY MATRIX FOR INCREASING PERSONAL LEADERSHIP CAPACITY

Outcome	Competencies	Breakdown	Knowledge	Know-how	Wisdom
Leadership for change	Aligning people, systems, and resources	Communicating			
		Listening			
		Teaming			
		Living values			
		Creating a shared vision			
		Matching systems to vision			
		Understanding interactions of people			
		Building trust			

Source: Text taken from Hall, M. (1996). *Proceedings: The 1996 NTL Conference: Leaders and Change*. "Increasing Leadership Capacity to Transform Organizations" College Park, MD: The University of Maryland.

APPENDIX C

TABLE 4. CAPACITY MATRIX FOR INCREASING PERSONAL LEADERSHIP CAPACITY

Outcome	Competencies	Breakdown	Knowledge	Know-how	Wisdom
Leadership for change	Motivating and inspiring others	Enabling risk-taking			
		Removing barriers			
		Promoting strategic thinking			
		Fostering innovation			
		Enabling all to empower themselves			
		Embracing diversity			
		Managing conflict			
		Supporting efforts			
		Continuous communication which connects to values			

Source: Text taken from Hall, M. (1996). *Proceedings: The 1996 NTL Conference: Leaders and Change*. "Increasing Leadership Capacity to Transform Organizations" College Park, MD. The University of Maryland.

APPENDIX C

TABLE 5. CAPACITY MATRIX FOR INCREASING PERSONAL LEADERSHIP CAPACITY

Outcome	Competencies	Breakdown	Knowledge	Know-how	Wisdom
Leadership for change	Managing change	Ensuring a sense of urgency			
		Creating the guiding coalition			
		Developing a vision and strategy			
		Communicating the change vision			
		Empowering broad-based action			
		Generating short-term wins			
		Consolidating gains and producing more change			
		Anchoring new approaches in the culture			

Source: Text taken from Kotter, J. (1996). *Leading Change*. Boston: Harvard Business School Press.

THE PHOENIX RISES

**Col Randy Davis, USAF, LTC Bill Phillips, USA,
and Lt Col Bud Vazquez, USAF**

The story of how this acquisition program rebounded from the brink of extinction to a model of reduced-cost and ahead-of-schedule production illustrates how determination, the use of integrated product teams, the program executive officer system, and the process approach to manufacturing can produce results.

Truth is a function of time.

—Brig Gen Ron Kadish
C-17 System Program Director
1993

Secretary of the Air Force, Dr. Sheila Widnall, used to joke that the phrase, “the troubled C-17 program” was really all one word. Accordingly, there are many accounts describing how the C-17 “Globemaster III” airlifter program got into trouble. Surprisingly, no one has tried to capture the specifics of the even more remarkable story of how the C-17 program got out of trouble. This article will tell that story.

We will begin with a short description of the aircraft and the requirement for it. Then, to put the ultimate success of this major acquisition program in proper context, we provide a brief review of the program’s troubled past. Following this review, we’ll cover the salient events—in the Pentagon, program offices, and the

McDonnell Douglas plant—that substantially contributed to the remarkable turnaround. We conclude with an in-depth look at lessons learned that could benefit other programs.

THE AIRCRAFT AND THE REQUIREMENT FOR IT

The C-17 aircraft program is the U.S. Air Force’s effort to develop a modern airlifter capable of meeting the worldwide air mobility needs of the Department of Defense (DoD). In the late 1970s, and after the cancellation of the YC-14 and YC-15 programs, the need for an aircraft capable of carrying large payloads to aus-

tere fields remained. The formal requirement for the C-17 was thus identified in 1980. The aircraft was specifically designed to carry modern combat weapons of U.S. ground forces directly into airfields near the conflict. This capability is known as "direct delivery": a strategic airlifter is able to deliver to tactical assembly areas without an intermediate stop. Perhaps most important, the C-17 will also provide a way to move "outsize" cargo (very large equipment like the M-1A Abrams tank, or the Multiple Launch Rocket System—equipment that cannot fit on today's C-141s or C-130s) for inter- and intra-theater airlift. The direct delivery dimension with an outsize airdrop capability will serve to significantly enhance airlift support to combat forces in the field and improve the mobility of general purpose forces.

The aircraft is a high-wing, T-tailed airlift aircraft. It is powered by four Pratt and Whitney PW-2040 engines with the military designation F-117. The engines are high bypass ratio fan jets very similar to those that have been used on Boeing 757 aircraft for years. The C-17 is the first modern, fully integrated, all electronic cargo aircraft. The design includes a quad-redundant electronic flight control system and fully automatic electronic monitoring of all systems to enable the aircraft to be fully supported by an aircrew of three

people: two pilots and one loadmaster.

Technologically, the heart of the C-17 is its propulsive lift system, which uses engine exhaust to augment lift generation. By directing engine exhaust onto large flaps extended into the exhaust stream, the C-17 is capable of flying steep approaches at remarkably slow landing speeds. This equates to the aircraft's ability to land payloads as large as 160,000 pounds on runways as short as 3000 feet.

Once on the ground, its ability to turn in a small radius, combined with its backing capability, allows the C-17 to maneuver into and out of tight parking spots as well as turn around on narrow runways. This ground maneuverability in tight quarters enables this aircraft to deliver more cargo to small airfields with limited parking space in a shorter time, increasing "throughput."

Finally, throughout its design, the contractor—McDonnell Douglas Transport Aircraft Division in Long Beach, CA—placed major emphasis on reliability and maintainability, which paid dividends in reduced maintenance manpower and spares requirements. The aircraft was designed with the maintainer in mind, and not as an afterthought. These reduced support costs, combined with the three-person crew and greater airlift productivity, serve to yield low life-cycle costs.

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TROUBLED TIMES—A BRIEF REVIEW

I have decided to put you on the C-17 program....say your prayers.

—Note from the Air Force program executive officer to one of the authors, June 1993

Just how did the C-17 program get into trouble? As one might suspect, there are many reasons. Most notable of all is that the contractor, McDonnell Douglas Corporation's Transport Aircraft Division (located in Long Beach, CA), throughout the late 1980s and early 1990s, was consistently behind schedule and over budget on the program.

The first C-17 scheduled to fly (known as "T-1") became airborne nearly 18 months after the date indicated in the contract. Thanks in part to the fixed-price development contract, and due to the sting of the A-12 program cancellation, the company was suffering financially. In fact, there was considerable concern within the Pentagon's acquisition and contracting communities about the company's viability. These tight purse-strings constrained the ability of corporate managers to invest in much-needed process and equipment improvements. To compound these woes, the company had a tumultuous experience implementing a total quality management system (TQMS), wherein a large number of experienced managers were laid off. To make matters worse, in hearings before the House Sub-Committee on Government Operations, the Air Force was accused of making improper progress payments to McDonnell Douglas that, in effect, were "bailing out" the struggling corporation. The Air Force was even accused of ac-

cepting the aircraft with structurally weak or "unsafe" wings.

After T-1 finally flew on its maiden voyage in September 1991, it had a series of fuel leaks, resulting in a highly publicized grounding (for about three weeks). The aircraft's aluminum-lithium alloy flooring had many problems associated with cracks. The failure to initially use a computer-aided design and manufacturing (CAD/CAM) system to design the aircraft caused both design and production problems.

All of this culminated in the Congressional decision to reduce the number of aircraft purchased (to 4 from an original 6 in 1993, and to 8 from an original 12 in 1994). These actions helped to drive a deeper wedge between the program office and the contractor. McDonnell Douglas found itself in a position of reduced buys, and therefore cut personnel to compensate for the reduced revenue. This action inhibited its ability to take advantage of learning curve efficiencies, made it tougher for the company to attract and retain quality subcontractors, and resulted in greatly reduced morale and increased chaos. The program was dangerously close to cancellation.

THE TURNAROUND

The C-17 program's incredible turnaround truly began in late 1993—but the year did not exactly begin well for it. In another well-publicized maneuver, Secretary of Defense Les Aspin forced former program director Maj. Gen. Mike Butchko to retire, and punished two other general officers and a senior civilian over the

"bailout" controversy. The DoD's senior acquisition leaders recognized the dilemma the program faced. Relations between the contractor and the government were strained to the limit. The Air Force blamed McDonnell Douglas for failure to perform up to the standards of the contract. McDonnell Douglas blamed the government for "requirements creep," and for expensive constructive changes to the contract. Thus, the contractor had staked a series of contractual claims worth over a billion dollars against the government. The program had reached an impasse.

Hunting for a way out of the logjam, Under Secretary of Defense for Acquisition and Technology (USD[A&T]) John Deutch commissioned a Defense Science Board task force to study the program and to make recommendations. The leaders for

"The Air Force blamed McDonnell Douglas for failure to perform up to the standards of the contract. McDonnell Douglas blamed the government for 'requirements creep,' and for expensive constructive changes to the contract."

this effort were Air Force Lt. Gen. Jim Fain, who was serving as the commander of the Aeronautical Systems Center in Dayton, OH, and Robert A. Fuhrman, the respected and retired chief operating officer

of Lockheed Corporation. The program's landscape was littered with three major land mines, and it was these three that the task force had to negotiate through and around:

- The fixed-price contract did not account for the unknowns of a development program, and led to incessant

contractual and legal bickering over who was to pay.

- Congressional changes laid in a four-year gap between when McDonnell Douglas "won" the C-X competition, and when development would be fully funded. This gap also saw legislation forcing the Air Force to buy 50 C-5Bs and 44 KC-10s.
- Last, and certainly not least, poor performance by McDonnell Douglas was apparent in all aspects of the program.

THE SETTLEMENT

In order to effect change, the task force knew that both parties would have to agree to substantive concessions. To make a very long story very short, McDonnell Douglas was persuaded to drop all its current and pending claims against the government, and they agreed to invest more than \$100 million into improved manufacturing processes and equipment, a modern management information system, CAD/CAM, an ISO-based advanced quality system, and a host of other small but needed changes. As the government's portion of the settlement, the Air Force increased the contract ceiling price by \$237 million (effectively paying that amount to the contractor), and relaxed a number of specification requirements to reflect the change to a post-Cold War world.

In the late summer of 1993, there was a concerted and highly guarded effort to develop a way to wipe the slate clean for both government and contractor. It was one of the better-kept secrets in the infamously leaky halls of the Pentagon. Specifications were rewritten to account for shortfalls and to represent actual opera-

tional requirements,¹ various government and contractor legal claims were added up, and vigorous debates on the appropriate (money, consideration, additional investment, etc.) relief ensued. On January 6, 1994, at least five months later than the Office of the Secretary of Defense (OSD) and Air Force staffs had originally anticipated, the settlement was approved and signed by John Deutch and John McDonnell.

If there is one truth about the turnaround of this program it is that one can hardly underestimate the importance of the settlement. The settlement provided all involved the *tabula rasa* needed to continue building the aircraft, moving the program focus back to customers, managers, and engineers, and away from the lawyers and contracting officials.

Knowing the value of a goodwill gesture in the never-ending legislative branch debate, McDonnell Douglas began to make much-needed investments even before the agreement was formally signed. The new management teams could move forward as teammates, rather than as adversaries. Furthermore, the settlement gave everyone involved in the program a sense of optimism that had been long gone. Things were looking up! At this point, it was in the labyrinth of the Pentagon where the road to recovery began to build upon the settlement's optimistic momentum.

MEANWHILE, BACK AT THE PENTAGON

On November 8, 1993, the fifth meeting of Defense Acquisition Board (DAB),

which had begun in August 1993, concluded. John Deutch left room 3D1019, and called an executive session in his office. Shortly thereafter, as the generals and senior civilians scurried back to their offices, the respective staffs were hastily assembled to begin what would become a concentrated effort to turn the C-17 program around.

The decision that rumbled through the Pentagon was hardly a surprise to those close to the program and its turbid history. Rather than the planned 120 aircraft, DoD would commit to buying no more than 40 C-17's, with subsequent buys predicated on improved C-17 performance, quality, and a marked reduction in price. The time pressures were immense: the acquisition community had 24 months to do it or buy a different airlift aircraft. At the DAB meeting, data presented

"If there is one truth about the turnaround of this program it is that one can hardly underestimate the importance of the settlement."

by the Institute for Defense Analyses (IDA) showed that if the Globemaster III did not perform up to specifications, mixed buys of C-17s and Boeing 747-400 freighters might be a cost-effective option to the previously planned 120 C-17s. Deutch, who was soon to become the Deputy Secretary of Defense, delegated the responsibility for turning this concept into reality over to Rudy deLeon, the Under Secretary of the Air Force. The Air Force's acquisition community and C-17 program brain trust—Deputy Assistant Secretary Darleen Druyun, the incoming Program Executive Officer (PEO) Brig. Gen. Jim Childress, Airlift Directorate

Brig. Gen. Jim Richards, and Program Director Brig. Gen. Ron Kadish—had a huge task before them.

Work began immediately on three priorities. First, efforts to turn the C-17 program from a disaster into a viable program had to be continued at an ever-heightened pace. Second, a competitive alternative to the C-17, primarily in the form of a slightly modified Boeing 747-400 freighter, and revitalized C-5 (to become known as the C-5D), had to be ready to be executed by the scheduled November 1995 DAB meeting—no small task considering there weren't even people assigned to these projects yet. Third, a process had to be devised that pulled all the constituencies, personalities, and details together for another DAB meeting not later than November 1995.

Most of these issues fell squarely into the lap of the new Air Force program executive officer for tactical and airlift

"Brigadier General Childress immediately and correctly recognized that a detailed plan had to be built, coordinated, and executed, and that this plan would require the 'buy-in' of all of the key people in the Pentagon."

(AFPEO/TA), then Brig. Gen. Jim Childress. Having arrived from the F-15 System Program Director (SPD) position at Warner Robins Air Force Base in the summer of 1993, Childress was assigned as

SAF/AQX, or the Directorate of Management Policy and Program Integration. He was thrust into the PEO position when Lt. Gen. Ed Franklin left to take command of Hanscom Air Force Base's Electronic Systems Center. He and his C-17 SPD, Brig.

Gen. Ron Kadish, and the new McDonnell Douglas program manager, Don Kozlowski, had the monumental task of working to make good on the myriad of demands and promises. Given the long-lead time to "cut-in" production line improvements in order to see tangible results within 24 months, they were already behind schedule.

THE CHILDRESS PLAN

Brigadier General Childress immediately and correctly recognized that a detailed plan had to be built, coordinated, and executed, and that this plan would require the "buy-in" of all of the key people in the Pentagon. This plan, and its many evolving parts, captured the key events and the process by which the Air Force proposed to bring the salient parts together by November 1995. There were a few key components of the plan.

Childress envisioned continuing the highly successful chief executive officer (CEO) meetings started by his predecessor, Lt. Gen. Ed Franklin. These small and confidential meetings between the Secretary of the Air Force and John McDonnell (and including a small group of the most senior Air Force and Army leaders) kept issues squarely in the limelight for immediate decisions. They continued quarterly for the next two years.

He created and implemented what became known as the "Milestone III Steering Committee." This was another quarterly gathering aimed at managing the inevitable process issues that were certain to appear on the way to the DAB. The group was chaired by Rudy deLeon, the Under Secretary of the Air Force. Unlike the CEO meetings, this forum had wide membership, and included OSD represen-

tation. It was an integrated process team (IPT) at its best and at the Pentagon staff's highest level.

In addition, given the complex process needed to force all the disparate pieces to come together by November 1995, the acquisition community could not afford disagreement with the process used to get there. Accordingly, General Childress proposed a major briefing to the DAB principals a full year ahead of time, in November 1994. This evolved into a full-blown DAB meeting (affectionately known by many as a "practice DAB") wherein the plan to get to the Milestone decision in November 1995 was approved. This was another stroke of genius. The PEO had substantially lowered the risk that there would be disagreement over the approach at the Milestone DAB meeting, when it would be too late to do much about it.

These initiatives were applauded and supported up and down the chain of command. General Childress had gained the planning "high ground" in the Pentagon. It was now his plan, and suggestions to change it went to him—rather than the PEO having to get it issued from "on high." There were three main "annexes" to the attack plan. Figure 1 shows a simplified process plan used to integrate the nondevelopmental airlift aircraft (NDAA) competition with the C-17 program. Figure 2 shows the overall management plan for managing the process through 1994 and 1995. Figure 3 shows the detailed plan for the last 180 days before the DAB meeting—the period when pre-DAB activity reaches a crescendo.

SURPRISE! THE CUT TO FOUR

Early in 1994, and just after the settlement was finalized, DoD and the Air Force

prepared for their annual Congressional testimony. As expected, Air Force airlift testimony supported Deutch's decisions and made the continued signs of C-17 technical progress prominent. Nonetheless, the key professional staffer for the House Armed Services Committee (HASC), Bruce MacDonald, was nonplused, to say the least. A strong advocate of using commercial airlifters like the Boeing 747 in the years preceding the Deutch-led DAB session, in late April MacDonald

convinced the HASC members to recommend a cut from the plan of six C-17s for the sixth production lot, down to four. The legislation would then use the "savings" to begin buying commercial airlifters.

This recommended cut would be disastrous to DoD plans. It would not allow the Deutch plan to unfold, it would not give McDonnell Douglas time to make improvements, and it would not provide any major near-term benefits to U.S. strategic mobility capabilities. Just as McDonnell Douglas was making progress, the reduction would increase the price of the airplane, probably cause layoffs, and wreck the program. Something had to be done—and quickly.

Rudy deLeon called the Air Force brain trust together that Friday evening to develop the plan that would counter this legislative threat. It called for a full-court press to save the C-17. Senior leaders

"...given the complex process needed to force all the disparate pieces to come together by November 1995, the acquisition community could not afford disagreement with the process used to get there."

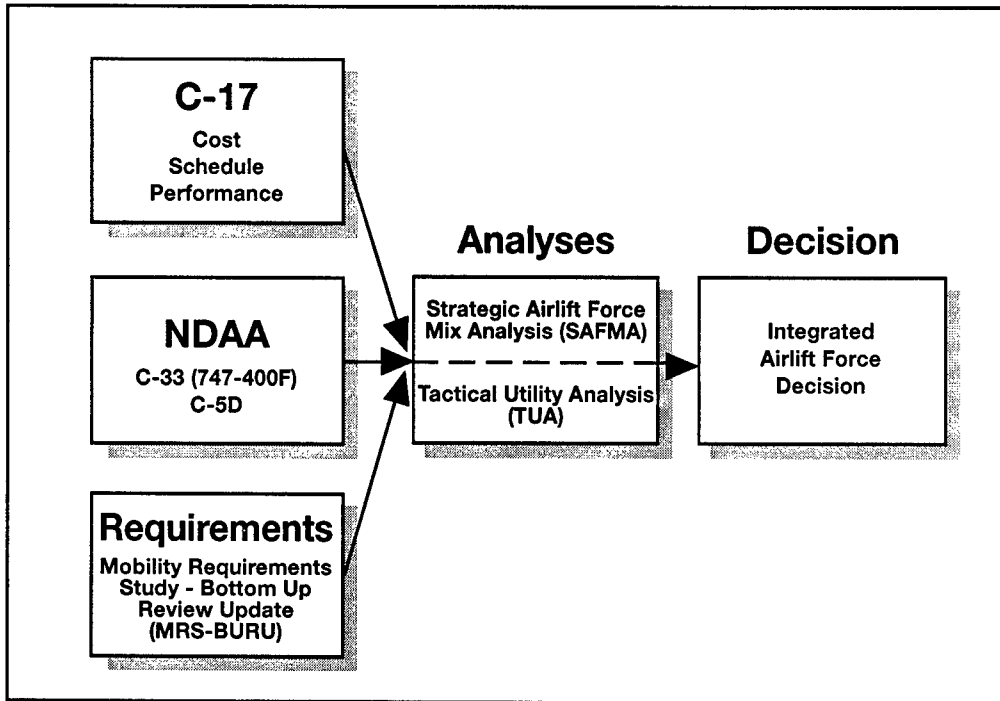


Figure 1. Decision Process

throughout the Air Force and DoD would be mobilized to meet with, write to, or call key members of Congress. A bipartisan alliance of Democrats and Republicans formed the nucleus of the effort. A "white paper" making the case for restoring the cuts and allowing the Deutch plan to unfold was needed. And it would have to be built over the weekend by a small team of Pentagon action officers, division chiefs, and OSD lawyers. The White Paper made a convincing case of all the reasons the cut would be counterproductive and was a remarkable success. As a result, in an unprecedented move, the cuts recommended by the HASC were overturned in a vote on the floor of the House of Representatives. The C-17 was saved, at least temporarily.

JOINTNESS AND THE TEAM EFFORT TO SAVE THE C-17

A prime lesson for those in the Pentagon was that jointness is goodness. Without the vigorous, vocal, and continual support of the U.S. Army, the C-17 would likely be a relic of the past, rather than the core airlifter of the future. In the Army's Concepts, Doctrine & Force Policy Division (DAMO/FDQ), then-Brig. Gen. John Riggs and his action officer, then-Maj. John Burns, were assigned to stay actively engaged in the program. Lt. Cmdr. Dan Page's role as the Army liaison to the program office in Dayton took on heightened importance. The Air Force acquisition community welcomed this participation and did its best to keep the Army informed, involved, and working issues that needed Army help. For instance, at one time the

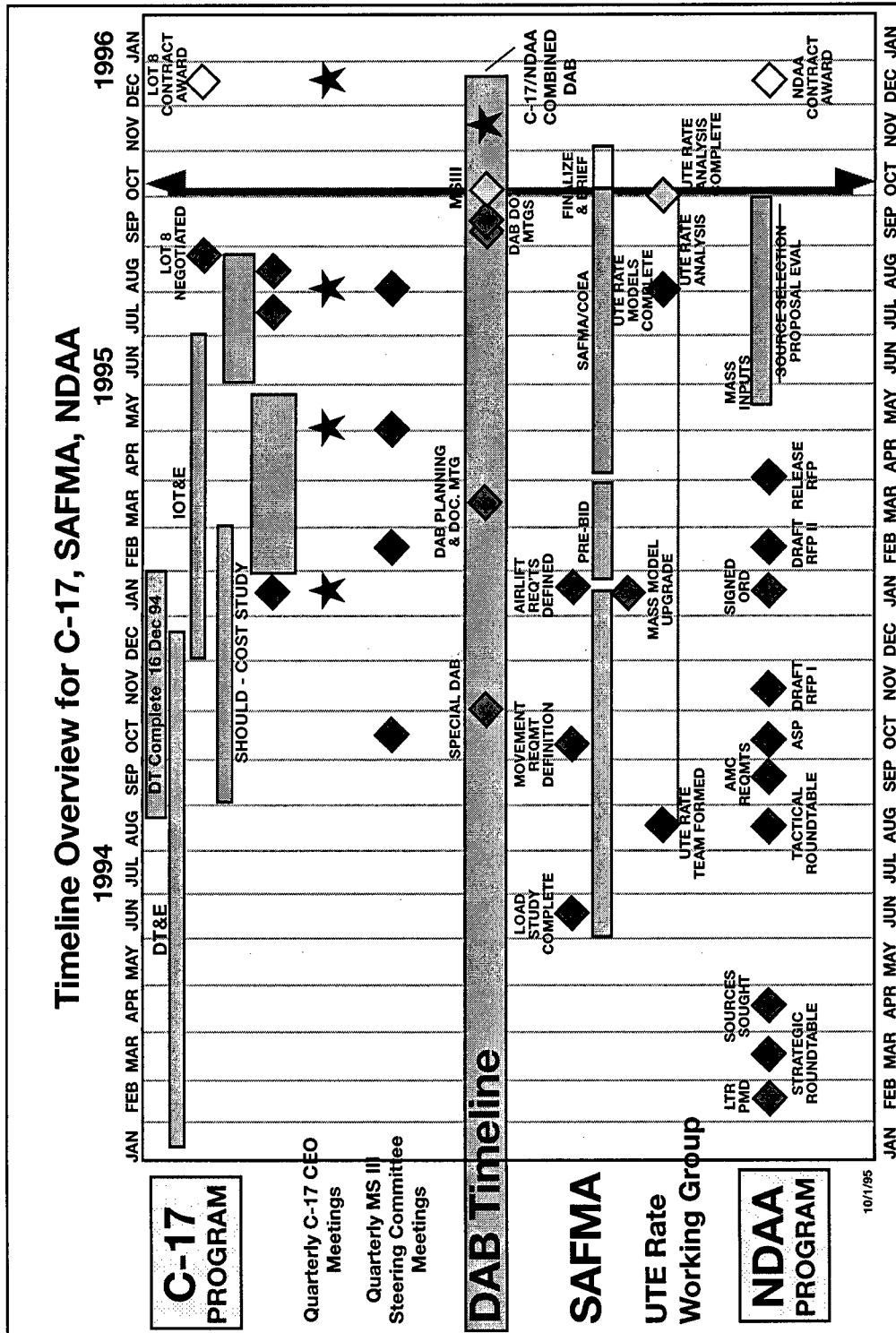


Figure 2. Timeline Overview for C-17, SAFMA, NDAA

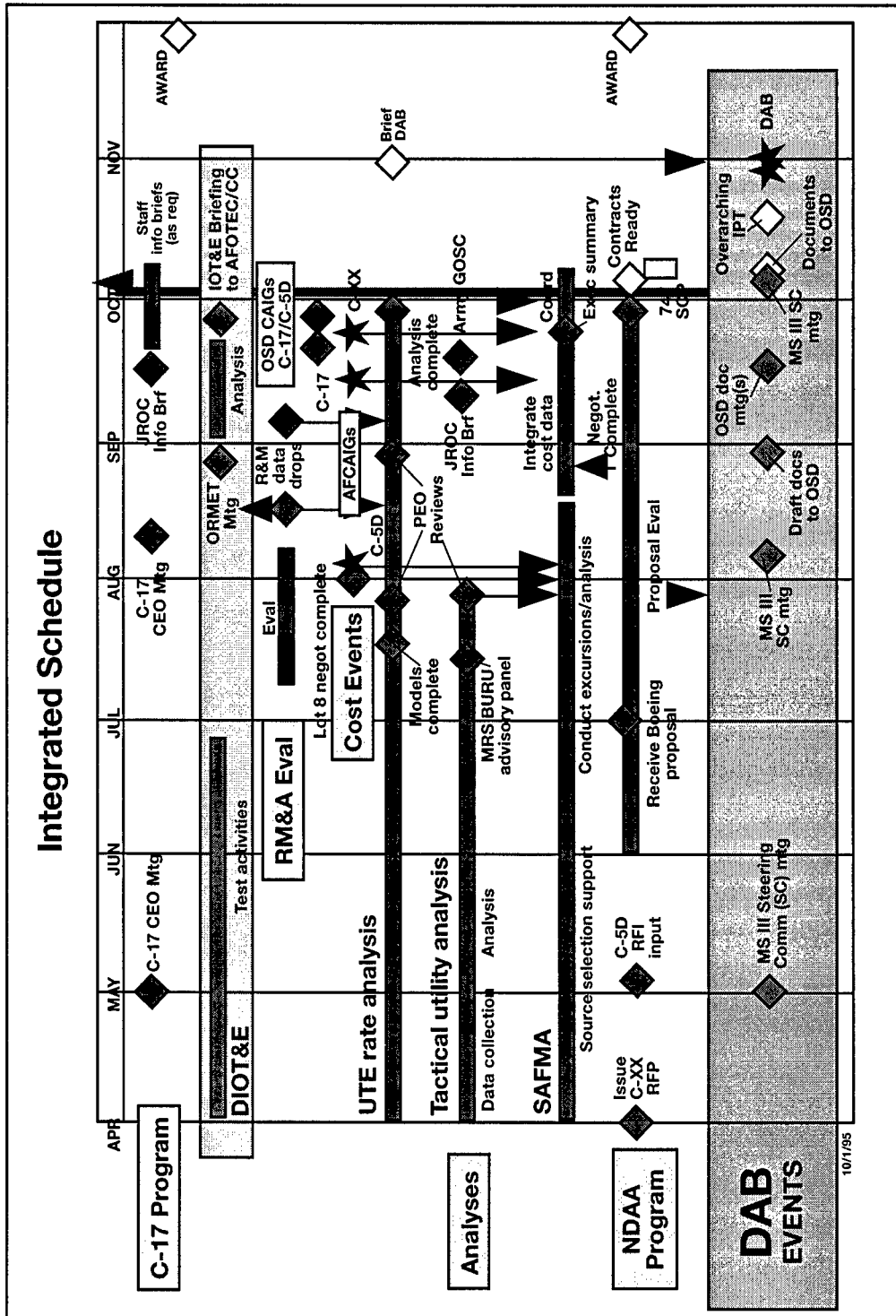


Figure 3. Integrated Schedule

Joint Staff alleged that there were no plans for strategic brigade airdrop. John Burns' research found no less than 6 historical examples and 10 active plans that program proponents used to counter-punch our way to advantage. When the Army's plans for Direct Delivery proved to be more a concept than an operational plan, Riggs and Burns helped motivate several tactical analyses, that rightly accounted for the C-17's ability to deliver outsize equipment to tactical assembly areas, and that would greatly help prove the C-17's worth. The cooperative approach would work out tremendously.

THE ARMY—AN INVALUABLE PARTNER

The U.S. Army was considered by the Air Force to be ultimate user of the aircraft; and therefore a highly valued customer. The Pentagon, company, and the system program office (SPO) worked together to ensure that the Army was a full member of the team as the program turned the corner. An example of the high spirit of jointness exhibited under General Kadish's leadership was the joint effort to approve the C-17 for airdrop missions. After many fits and starts, new procedures and equipment were used to better meet the Army's needs. In a brigade airdrop "slice" demonstration in the spring of 1995, six C-17's successfully dropped more than 200 Army paratroopers and a large compliment of heavy equipment with absolute precision. This demonstration took place in front of a host of DoD distinguished visitors, including the DoD director of operational test and evaluation.

The strategic importance of the C-17 was quickly demonstrated in real life by the superb support the aircraft provided Operation Joint Endeavor. Having just

been designated as operationally capable, the aircraft was called upon to provide both strategic and operational lift for the NATO Implementation Force (IFOR) move into Bosnia. The aircraft demonstrated its superb mission flexibility in support of the IFOR Savo River crossing.

When flooding caused a need for additional bridging sections, innovative people discovered these "outsize" sec-

"A prime lesson for those in the Pentagon was that jointness is goodness."

tions could be loaded onto flatbed trailers and driven right on and off the aircraft. The sections were delivered by C-17 and driven to the river. The time savings for this outstanding example of direct delivery was measured in hours rather than days. Further, within the first six months, the C-17 had flown almost half the tonnage in only one quarter of the missions. This equates to 508 missions; 4108 passengers (27% of all passengers); and 12,610 tons of cargo (48% of all cargo carried into the region). The aircraft's performance has been, and continues to be, truly exceptional and critical to the successful sustainment of Operation Joint Endeavor. The C-17 has proven its worth in its very first test.

THE "SHOULD COST"

We mentioned a key objective was to lower the cost of buying C-17s. A direct impact of the decision to temporarily cap the program at 40 was to greatly inflate the cost of each C-17. During the Congressional reporting cycle in December of 1993, the total program cost (research, development, production, and mainte-

nance) divided by 40 worked out to well over \$500 million per aircraft. The acquisition community could hardly endure these headlines and expect a 41st aircraft. At the suggestion of DoD Inspector General Derek Vander Schaaf, and with the concurrence of deLeon, the Air Force was asked to perform a top-to-bottom cost

"The strategic importance of the C-17 was quickly demonstrated in real life by the superb support the aircraft provided."

"scrub" aimed at reducing program cost. After some initial pause (several of these studies had occurred with little to show), a new

and high-powered approach took shape. Lt. Gen. Dick Scofield, General Fain's replacement at Wright-Patterson Air Force Base, OH, would lead an effort aimed not at identifying "potential" savings (as was common in past attempts), but at implementable savings.

This minor shift was tremendously important. The focus was now on realistic and realizable savings, and under Darleen Druyun's leadership at the Pentagon, the group worked miracles. Using the investment monies from the settlement and the corporate coffers, the team searched for the high-payback items with great success. Of great import, and precisely because the aim was on implementation, the contractual vehicles performed in parallel so that time (and the associated opportunity for payback) would not be wasted. In addition, all the stakeholders—the auditors, the contractors, and the government—agreed to a single cost model. By the summer of 1995, the team identified cost savings that brought down the cost of the C-17 to little more than that of a Boeing 747-400. The

C-17 now cost \$172 million in "flyaway cost" per aircraft in constant 1995 dollars. This was a number many Pentagon bureaucrats thought impossible to reach, and this achievement gave rise to more optimism.

Occurring almost simultaneously with events in the Pentagon, and shortly after the settlement, was another watershed event vital to the turnaround. Senior leadership at both the SPO and McDonnell Douglas changed. Brig. Gen. Ron Kadish transitioned from his position as F-16 program director to the directorship of the C-17 program. McDonnell Douglas put Don Kozlowski, a McAir veteran program manager from St. Louis, MO, in charge in Long Beach. These two leaders shared common goals: turn the program around, make it successful, and do it post haste.

THE PROGRAM OFFICE-CONTRACT OR PARTNERSHIP

Perpetual optimism is a force multiplier.

—Gen. Colin Powell

The first steps the new leadership took involved personnel and organizational structure. They jointly formed "mirror image" integrated product teams (IPTs) to help them to manage the program as partners. These IPTs were consciously organized around C-17 product-related areas, and in the long run proved massively successful for program execution. General Kadish and Kozlowski empowered these IPTs. Each team received talent from all of the key functional areas of expertise, and the team leaders had the trust and confidence of the program leadership to the

extent that they made decisions for program execution. The initiation of IPTs facilitated joint decision making, and promulgated full and open communication. They allowed program managers on both sides to focus on program events, as they jointly worked the issues. The government and the contractor jointly developed an integrated master plan that included lower level integrated schedules.

Integrated program management also resulted in the following: joint configuration management control; quarterly joint executive program management reviews; and a program reporting system that consolidates issues and tracks actions. All of this fostered the feeling that both the contractor and the SPO shared a common destiny. Perhaps the best way to describe what integrated product development brought to this program is to contrast the old way of doing C-17 business with the way things worked once IPTs formed. The old way is best characterized this way: different organizations, functional process focus, us versus them, slow and guarded communications, plans integrated at program level, multiple schedules, and functional budgets. The new way of doing business included: aligned organization, product focus, we, rapid and open communications, team planning, an integrated master schedule, and team budgets.

Communication was another key to success. Any problems, potential problems, or obstacles in the way of progress were dealt with openly. General Kadish's motto "bad news doesn't get better with age" was clear guidance to communicate openly and honestly, without fear of retribution.

Kozlowski brought a renewed sense of purpose to the McDonnell Douglas C-17

team. He implemented major organizational changes and installed proven performers in key team positions. Most important, he essentially reinvented senior management's relationship with the employees. Among his key leadership achievements were: a fresh focus on team solutions and accountability, 75 percent reduction in lost work days due to accidents on the production floor, employee involvement and gain sharing, a renewed relationship by objectives with the UAW union, employee recognition programs, increased emphasis on skills training, and an 80 percent reduction in grievances.

General Kadish and Kozlowski set up three definitive goals at the outset, with a relatively near-term focus. These goals were: to achieve initial operating capability (IOC) in January 1995, to successfully complete the reliability, maintainability, and availability evaluation (RM&AE) in July 1995, and to successfully complete the DAB review in November 1995. To ensure consistency, each of these three goals had joint integrated master plans and integrated master schedules associated with them. Each IPT aggressively managed its portion of all three goals.

The first goal, IOC, involved delivering the 12th operational C-17 to the 437th Air Wing at Charleston Air Force Base, SC. All 12 aircraft had to be fully supportable, and we needed 48 fully qualified aircrews for IOC to be declared. The planning and scheduling "drills" just discussed

"These two leaders (Brig. Gen. Ron Kadish and Don Kozlowski) shared common goals: turn the program around, make it successful, and do it post haste."

Table 1.
RM&AE Results for the C-17

Parameter	Actual Percent	Req. Percent	What's Good
On-time departure reliability	99.20	n/a	n/a
Mission completion success probability (MCSP)	97.50	86.00	Higher
Mean time between maintenance (inherent) MTBM(I)	3.94	1.31	Higher
Mean time between maintenance [corrective] MTBM(C)	1.81	0.63	Higher
Mean time between removal (MTBR)	8.47	2.26	Higher
Maintenance man hours per flight hour (MMH/FH)	3.45	27.7	Lower
Mean man hours to repair (MMTR)	2.50	8.16	Lower
Mission capable (MC) rate	90.70	80.80	Higher
Fully mission capable (FMC) rate	85.10	73.00	Higher
Note: Requirements and goals above are based on growth curves leading to mature values. 1. RM&AE numbers based on 15,000 hr (est). 2. Mature numbers based on 100,000 hr.			

had uncovered major disconnects in time for us to fix them. The Air Mobility Command commander declared IOC on January 17, 1995.

The second goal, successful completion of the RM&AE, involved flying all 12 of the 437th's C-17s at an up-tempo pace for 30 consecutive days. The plan called for C-17 operations at small austere airfields, transatlantic long-haul missions, and constant "quick turnarounds." The evaluation called for collecting extensive sortie generation rate data, mean time between failure data, mean time to repair data, and on-time takeoff data. In addition, mission completion success rates were monitored closely. This exercise took place during July and August 1995, and the C-17 per-

formed magnificently. Key results are shown in Table 1.

The third and final goal, successful completion of the combined C-17 and NDAA DAB session, was reached early in November 1995. Certainly the successful achievement of the first two goals contributed mightily to this outcome. It will go down in acquisition history as one of the smoothest and least controversial DAB meetings ever. The ultimate decision, announced by Deputy Secretary of Defense John P. White, was for a total buy of 120 C-17s, and a discontinuance of the NDAA program.

Having cleared the initial three program goals with flying colors, General Kadish and Kozlowski refocused the C-17 team

on three new goals: deliver and sustain a quality C-17 fleet, improve the weapon system's capability and support, and lower the life cycle cost. They developed an innovative way to separate C-17 contracts to provide better visibility into cost performance. The result was a scheme to orchestrate three discernible contracts: the production contract to correctly isolate flyaway cost to the production contract; the performance enhancement and product improvement (PE/PI) contract to directly manage the enhancement process; and the field support contract to directly manage the field support expense. Clearly, there was a need to reduce the cost of the C-17. Therefore, the SPO and McDonnell Douglas embarked on a journey to make the aircraft more affordable. This effort would soon intensify with a major effort in 1994 and 1995 to enhance affordability.

There were two basic ways to cut costs: through greater efficiency or through design changes. To achieve greater efficiency, the focus was on lowering indirect costs, lean aircraft initiative concepts, high-speed machining, outsourcing, low-cost suppliers, production span time reductions, and modern assembly techniques. On the design change side of the equation, the focus areas were design for manufacturing and assembly, avionics technology upgrades, and commercially available, highly reliable microcircuits. The company began to focus on these ideas, and it began to pay off almost immediately. The ultimate results of all of these cost reduction efforts were impressive and irrefutable. McDonnell Douglas' investment into the program, combined with nearly \$4 billion in cost reduction initiatives, resulted in lowering the flyaway cost of a C-17 from approximately \$275

million to \$172 million (CY\$95).

In addition, General Kadish initiated a unique award fee concept. His award fee plan focused on program benefits, with an eye toward initiatives to further reduce the cost of the C-17, and toward encouraging management responsiveness and program integration. This served as a highly effective motivator, as significant progress was made in all areas.

BUILDING SUCCESS IN LONG BEACH

A partnership is fragile—it must not be taken for granted!

—Col. Gene Kluter
Commander, DCMC
McDonnell Douglas, 1995

The Defense Contract Management Command (DCMC) at McDonnell Douglas in Long Beach played a major role in the C-17's turnaround. The Defense Contract Management Command (formerly known as The Defense Plant Representative Office, or DPRO) provides contract administration services support for the C-17 SPO by ensuring that McDonnell Douglas complies with contractual requirements. The SPO is the primary DCMC customer. The DCMC maintained active involvement with every aspect of contractor operations, providing a variety of services including pricing and negotiation, technical support, engineering and production surveillance, property management, quality assurance and flight acceptance of aircraft.

Prior to 1993 an adversarial relationship existed between DCMC Long Beach and McDonnell Douglas. As previously

mentioned, McDonnell Douglas was behind schedule while contract costs continued to escalate. This relationship resulted in significant distrust between government and contractor personnel, each blaming the other for failure to meet contractual requirements.

In August 1992, Air Force Col. Gene

"One of the most challenging and far-reaching DCMC initiatives involved a transition from functionally oriented government oversight to product- and process-focused oversight."

Kluter reported as the commander, DCMC McDonnell Douglas, Long Beach. The assignments of Brigadier General Kadish, Kozlowski, and Colonel Kluter completed the tripartite leader-

ship (SPO, McDonnell Douglas, and DCMC) that was essential to establishing a path toward success for the C-17 program. Colonel Kluter quickly established a positive, effective relationship with Kozlowski, which fostered a new era of partnership built upon trust. Furthermore, Kluter made a commitment to Kadish that DCMC would provide world class support for the C-17 Program. This partnership, built upon trust, cooperation, and a firm commitment to program excellence, then began its march toward reversing the disasters of the C-17 program.

DCMC CULTURAL CHANGE

One of the most challenging and far-reaching DCMC initiatives involved a transition from functionally oriented government oversight to product- and process-focused oversight. In 1994, DCMC began

to realign its functionally oriented divisions (engineering, contracts, and quality) into product- and process-focused teams. Implementation of this approach to contract administration reflected a significant cultural change for the DCMC workforce. The previous functional structure resulted in stove-piped organizations that inhibited open communication and cooperation. It promoted an adversarial relationship with McDonnell Douglas through application of an inspection and detection approach to determining nonconformances that were often subjective in nature. The functional approach did not facilitate determination of the root cause of a nonconformance; and most often resulted in temporary improvement and isolated solutions.

Conversely, the product- and process-focused teams created an efficient, cooperative approach to contract administration that focused on prevention of nonconformances and the design of quality into the product. The results were objective, continuous product improvements and systematic solutions to nonconformances. Furthermore, this approach fostered a synergy among DCMC team members (in engineering, contracts, and quality assurance), who shared their professional knowledge and skills.

Process-based management proved to be a critical component for eliminating production bottlenecks, as well as reducing costs and cycle time.

**—Randy Mizer, Vice President
for Program Integration
McDonnell Douglas
Transport Aircraft, 1997**

PROCESS-BASED MANAGEMENT

Probably the most significant enhancements to C-17 manufacturing process improvement, production efficiency, and cost reductions resulted from McDonnell Douglas' implementation of process-based management (PBM). PBM is a proprietary "management approach that defines an organization as a collection of processes and that focuses on customer satisfaction and waste reduction by defining, measuring, stabilizing, and improving processes."² It is a formal, seven-step process that results in disciplined systems and processes. It closely resembles the DCMC's Process Oriented Contract Administrative Services (PROCAS), a program designed to improve customer satisfaction, reduce contract costs, and reduce the cost of government oversight. Process-based management forms one major cornerstone for total quality management (TQM) at McDonnell Douglas. It is a proactive way to manage a process, prevent process nonconformances, and anticipate and implement process improvements.

McDonnell Douglas implemented PBM in full partnership with the DCMC and SPO, consummated by the signing of a formal teaming agreement. The Defense Contract Audit Agency (DCAA) was an active PBM participant as well. McDonnell Douglas and DCMC identified critical processes and designated "process owners" (MDC personnel) and "process specialists" (DCMC personnel). Process owners and specialists were empowered to manage the process and establish metrics (e.g., defects, timeliness, efficiency, and cycle time) to provide a balanced view of process health. McDonnell Douglas and government per-

sonnel shared the metrics' results and process health reports.

The successful results achieved from PBM implementation had an extremely positive impact on program execution. For instance, defects were reduced by 92 percent from P-16 (production aircraft) to P-22, while mandatory government inspection hours were reduced approximately 70 percent. Ramp span time was reduced by 61 days (46 percent) from P-7 to P-22. Timely execution of "root cause analysis" and resultant process improvements directly resulted in a 59 percent reduction of scrap, rework, and repair. Process improvements resulted in the elimination of fuel leaks on production aircraft that saved \$660,000 per aircraft. Production span time improved from 505 days for P-9 to 373 days for P-23, a 26 percent reduction.

Considering current trends, McDonnell Douglas expects to achieve another 48 percent reduction in production span time for aircraft P-40, scheduled for delivery in June 1998. Furthermore, based upon the government's confidence in PBM, DCMC reduced mandatory government inspection hours by 73 percent (which equates to 16 DCMC personnel), and a 500 hour-per-month reduction in Material Review Board hours. Greater reliance on PBM will lead to great contractor self-governance, which translates directly into cost avoid-

"One of the most challenging and far-reaching DCMC initiatives involved a transition from functionally oriented government oversight to product- and process-focused oversight."

ance to the taxpayer (from oversight to insight).

Process variability reduction (PVR) achieved tremendous success due to the implementation of PBM, coupled with investments in production tooling resulting from the settlement agreement. McDonnell Douglas implemented a total of 48 process variability reduction projects and 38 settlement-induced projects that resulted in significant cost savings. For example, the main landing gear pod was redesigned for easier manufacturing and assembly. The number of detail parts and fasteners were reduced from 1,792 to 37, resulting in 8,400 installation hours saved and \$103 million of cost savings for the remaining aircraft.

Furthermore, more efficient and effective production tooling was installed to reduce production bottlenecks. An auto-

mated rivet gauging tool referred to as "Genesis" was installed, which significantly reduced variability and rework costs. State-of-the-art fuselage alignment tools were also installed. New information systems that realigned daily work schedules to maximize production efficiency were employed. What's the bottom line, you ask? Effective implementation of process-based management and process variability reduction directly resulted in a better product, faster delivery at reduced costs, and much greater customer satisfaction.

STREAMLINING MILITARY SPECIFICATIONS AND STANDARDS

Few would argue with the premise that military specifications and standards add significant costs to government programs. In some cases these contractual require-



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ments do add value and are necessary to ensure that the product meets government needs. However, in many cases they do not add value, a trend recognized by leadership within the DoD. On June 29, 1994, Secretary of Defense William J. Perry issued a memorandum on specifications and standards. The memorandum "directed the use of performance specifications to the maximum extent practicable, and the development of a streamlined procurement process to modify existing contracts to encourage contractors to propose nongovernment specifications and industry-wide practices that meet the intent of military specifications and standards which impose government-unique management and manufacturing requirements."

Considering DoD guidance, McDonnell Douglas and DCMC performed a thorough review of contractual military specifications and standards. The mission was to "challenge the requirement" and retain essential performance requirements or tailor them to the C-17 program. During full-scale development of the C-17 aircraft, there were 243 contractual military specifications and standards. During Lot VII production, these were reduced to 30. The review further resulted in the current requirement of 5 military specifications and standards—a significant reduction. A few of the deleted specifications and standards are Mil-Std-1567A (work measurement), Mil-Std-965 (parts control program), Mil-Std-980C (foreign object debris prevention), Mil-Std-483 (configuration management), and Mil-Q-9858A (quality system). These requirements were replaced by commercial practices employed by McDonnell Douglas, and thus the cost associated with maintaining two sys-

tems—one for the government and one for the company—was reduced.

The deletion of Mil-Q-9858A occurred after McDonnell Douglas' successful implementation of an ISO 9000 compliant advanced quality system (AQS). Obtaining ISO 9000 compliance was not an easy task by any means. McDonnell Douglas, in partnership with DCMC, established a detailed implementation plan that included support of external consultants well versed in ISO 9000. Company and DCMC personnel underwent a rigorous training program, and numerous assessments were performed. In October 1995, DCMC issued a "Statement of the Qualification." The AQS resulted in improved process metrics, reduced cycle time to implement corrective action, increased focus on designing and building in quality, and continuous reduced process variability. Most important, the AQS is compatible with commercial quality systems; it thus reduces costs to the government by avoiding duplicate systems. In the June 1996 "Milspec Reform" publication, the USD[A&T] singled out the C-17 program's implementation of an ISO 9000 system as a success, resulting in "advanced schedule deliveries, cost savings of approximately \$100,000 per aircraft, and a 40 percent reduction in government quality inspection work force."

"The AQS resulted in improved process metrics, reduced cycle time to implement corrective action, increased focus on designing and building in quality, and continuous reduced process variability."

COMMUNICATION— A "VISION" FOR SUCCESS

Timely communication that clearly articulated the issues, concerns, and problems proved essential to the C-17 program's turnaround. This was a monumental task, considering the number of major and minor subcontractors, as well as the myriad of parts suppliers supporting the program. The DCMC tackled this problem by expanding the "partnership" to include all the major and minor suppliers.

"Timely communication that clearly articulated the issues, concerns, and problems proved essential to the C-17 program's turnaround."

A customer service center was established at Long Beach to "maintain communications and teamwork on the part of all of the suppliers and government organizations managing the C-17 program."

This included institutionalizing a formal structure for reporting issues, problems, required actions, and successes. The reports were consolidated into a keystone document called *Vision—C-17 Employed Around the World*.

The report provided a detailed, extensive look into the program's status from a manufacturing and program integration view. It included a "quick look" (executive summary) section followed by contract performance, product team performance, subcontracting management, and system program integration (SPI) sections. The executive summary provided a quick program overview to include major issues relating to cost, schedule, and perfor-

mance. The contract performance section provided a detailed look at cost and schedule, estimate at completion, progress payments, contract modifications, safety/foreign object debris, and the health of business and technical systems. The product team performance section provided extensive insight into aircraft systems (avionics, flight controls, mission equipment, and airframe), flight operations, air vehicle integration, and PBM. The subcontract management section provided a brief overview of the status of major suppliers to include component descriptions, issues, and delivery and quality ratings (red = unsatisfactory; yellow = marginal; green = satisfactory). The SPI section provided an extremely thorough analysis of program status at 38 major suppliers, to include cost, delivery, quality, and program rating. Most important, the report identified the key issues affecting performance that required action.

The customer service center prepared the *Vision* report monthly. The document was forwarded to key agencies for review and action as required. The center tracked the issues to ensure timely resolution, and thus ensured the elimination of roadblocks to program execution and greater customer satisfaction.

LESSONS LEARNED

The story of the C-17 program's remarkable turnaround highlights lessons learned that could benefit other programs. Among the most important of these are:

Never count on divine intervention. The settlement between McDonnell Douglas and the Air Force allowed the con-

tractor to begin with a clean slate. It was the major catalyst that fostered better communication and teamwork between the SPO and McDonnell Douglas. Nonetheless, it required an extraordinary lining up of the Congressional, OSD, and service "planets" that was extremely rare and unlikely to happen again.

Integrated product teams and the PEO system work. The teamwork that IPTs fostered proved invaluable, in part due to the fact that they were genuinely empowered by Kadish and Kozlowski. The teams aggressively attacked and achieved the program goals that the leadership laid out. Major General Childress and his staff did a masterful job conducting the DAB process, and "running top cover" in Washington, enabling the SPO to concentrate its effort on program execution. His savvy development of an executable NDAA alternative put the weight of competition onto McDonnell Douglas, and tangibly helped them get their act together.

Other lessons are:

- Enlist the vocal support of your customer. Keeping the Army well informed and deeply involved proved vital to program success.
- Assign action officers to orchestrate a Milestone III DAB at least one year in advance. This proactive approach served to get "buy-in" from key OSD participants early on, and gave them a sense of ownership in the success of the C-17 program.
- A process approach to manufacturing is extremely valuable; it allows problems to be fixed at their source. Root

cause analysis helped participants to focus on the problem's source, eliminating bottlenecks to program progress.

- Concentrate on a series of challenging yet achievable goals, and harness the energy of the combined contractor-SPO team to attain them. Once attained, establish a new set of goals. Program goals and objectives must flow-down into integrated plans and schedules. Hold IPT leaders accountable for achievement of their part of each goal. A well-functioning team will include four tiers of members. First-order members are the contractor, plant representatives, and SPO; second-order members are the SPO, PEO/mission area director, and service staffs; third-order members are the OSD; and the fourth order is Congress.

"Ultimately, all improvement boils down to the contractor's ability to perform."

- Use the public affairs office to develop a plan to disseminate the good news. It proved useful to get VIPs involved, allow them to fly on the C-17, and to let them hear the opinions of the people actually using the aircraft—both AMC aircrews and maintainers and Army soldiers.

Ultimately, all improvement boils down to the contractor's ability to perform. McDonnell Douglas' performance improved at a rapid rate throughout the recovery cycle of the program. The company began to routinely deliver high-qual-

ity C-17s ahead of schedule. Take charge! Seize the high ground on every issue. This includes issues other than just the ones you think you own. Finally, a brief array of Gen. Colin Powell's "rules" apply in the

C-17's case: "It ain't as bad as you think." "It will look better in the morning." "It can be done." "Check small things." "Share credit." "Have a vision." "Be demanding."

Col Randy Davis, USAF, LTC Bill Phillips, USA, and Lt Col Bud Vazquez, USAF, wrote this paper as part of their course work for the Senior Acquisition Course (SAC), a highly selective part of the National Defense University's Industrial College of the Armed Forces (ICAF) curriculum. At the time of their experiences, Colonel (select) Davis led an Integrated Product Team at Wright-Patterson AFB's C-17 Program Office, LTC Phillips commanded the DCMC McDonnell Douglas Huntington Beach, CA, facility (plant representative office), and Lt Col Vazquez was the director of airlift programs for the Air Force's Program Executive Officer for Tactical and Airlift programs in the Pentagon.

ENDNOTES

1. The original contract specifications were written to capture the C-17 performance proposed by McDonnell Douglas during the source selection. However, these were very much in excess of actual Air Force requirements stated at the time.
2. PBM is a management system proprietary to McDonnell Douglas. Permission was granted for use in this article. For further information about PBM, contact McDonnell Douglas.

A PROGRAM MANAGER TALKS: WHAT CONTRACTORS SHOULD KNOW

Deanna J. Bennett

In July 1997 U.S. Special Operations Command (USSOCOM) awarded three systems engineering and technical assistance (SETA) support contracts. Each contract has a \$150 million ceiling over the five-year contract life. The contractors were selected under a formal acquisition process. Some new strategies available under acquisition reform/streamlining were used in the solicitation and evaluation.

My recent experience as the program manager for USSOCOM's SETA acquisition has shown me that, despite the drive for open government communication and despite the years of contractors competing under substantially the same rules (with some adjustments at the margin because of acquisition reform and streamlining), too many contractors continue to hold misapprehensions about the government competitive acquisition process, penalize themselves through lack of understanding of the process, and make tactical as well as factual mistakes in the proposal preparation and discussion processes.

The purpose of the competitive acquisition process is not to weed out the unqualified (though this occurs as a by-product of the process) but to be able to make an informed selection from competent, qualified competitors. The purpose of this article is to share some of the lessons I've learned over my 25-year career in the Department of Defense (DoD) acquisition business about what contractors do wrong, specifically with respect to services type contracts, so they can become better competitors in the acquisition process. Although my USSOCOM SETA

acquisition experience precipitated this article, the examples and observations I make follow from the large number of acquisitions I've been associated with during my career.

UNDERSTAND THE ACQUISITION PROCESS

FACE TIME DOESN'T COUNT

This is a truth much denied in practice by industry. The formal acquisition process is built on objective evaluation of the proposal. Presenting information briefings

and getting “face time” with the program manager or the source selection authority or anyone else you presume is involved in the process counts for nothing in the acquisition process. It isn’t your marketing manager or program manager but your proposal that talks. (On the other hand, do take every opportunity in all forums to gain information about the customer’s requirements.)

PLAY BY THE RULES

There is a way to negatively influence the government’s perception of your company and possibly elicit unwanted government attention for your company. That is to attempt to get additional or insider or advance information about the proposal or its details. Word does get back to the contracting officer if a contractor has contacted government personnel to elicit information, and your company will receive direction from the contracting officer to play by the rules.

UNDERSTAND THE BASIC PROCESS

The basic underpinnings of the acquisition process are objectivity and fairness. All offerors submit proposals against the same Request for Proposal (RFP) containing the same statement of work and the same proposal instructions. All offerors are evaluated against the same objective evaluation criteria. The selection is made

based on the criteria established by the program office and published in the RFP. In general, at the most detailed level of evaluation, technical proposals are evaluated by individuals who have no access to the cost proposal. Cost and other sections of proposals are evaluated separately. At the next higher level, the results of all facets of the evaluation (e.g., technical, cost, management, past performance) are reviewed to give a full understanding of each proposal, proposals are compared with each other (using the results of evaluation against the objective evaluation criteria), and a recommendation for award is made. The Source Selection Authority, the highest level in the process, uses all the information and the recommendation in deciding on contract award.

GET AS MUCH INFORMATION UP FRONT AS POSSIBLE

Have the right people in the loop to gather the information. If there is a pre-solicitation conference or a pre-proposal conference or other forum for information exchange between the government and industry, have your program manager and contracts people attend, not just your marketing manager. (See “Face Time Doesn’t Count” above.) Regularly access the agency’s Web pages for up to date information. If you have questions, ask in whatever forum is available.

Deanna J. Bennett is a program manager in the Special Operations Acquisition and Logistics Center, U.S. Special Operations Command. She holds a B.A. degree in economics, an M.A. degree in political science, and a Master of Public Administration degree. She is a graduate of the Defense Systems Management College’s PMC 93-1 course and is a Defense Acquisition Corps member certified at Level III in both program management and communications-computer systems.

READ THE SOLICITATION

The three most important parts of any RFP that are essential to understanding the process applicable to any competitive acquisition are Sections L and M and the Statement of Work. Read and understand these completely. There will be a quiz—it's your proposal!

PREPARE A SOUND PROPOSAL

UNDERSTAND WHAT'S IN SECTION L

Section L contains proposal instructions. If there are page limitations on all or parts of your proposal and direction regarding type fonts, diagrams, and illustrations, they will be in Section L. Section L also defines proposal format and structure: what information should be contained in what format and in which volume of your proposal. Importantly, Section L also defines the substance of the proposal.

DON'T MAKE AVOIDABLE SECTION L MISTAKES

Read the instructions carefully! Too many times offerors make simple mistakes resulting from not following instructions contained in Section L. Most often the result is a lower evaluation rating. There are a number of easily avoidable, but common mistakes.

Exceeding page limits. A page limit seems like a very simple instruction to follow; however, occasionally an offeror will waste time and effort to produce pages that are never seen by any evaluator. Anything submitted above the page limit is removed from your proposal and disregarded in the evaluation process. Some-

times the pages are sent back to you. Another strategy used is equally futile: You cannot get around a page limit by referencing another part of the proposal containing additional information. The evaluation teams will evaluate only the specified number of pages in their assigned section of the proposal. Write to the point and fit into the allotted page limit.

Putting information in the wrong place. This has the same effect as submitting too many pages. For example, putting footnotes in your cost proposal that expand on or clarify fine points in your technical proposal for a services type of contract may have no effect on technical evaluation: Technical evaluation teams have no access to the cost proposals and may never see the footnotes.

Assuming evaluation team osmosis. Putting something in one section of a proposal does not guarantee that evaluators of another section will read or be aware of it through some kind of team mental osmosis. For example, if a particularly innovative process is proposed that bears both on the overall

management of contract performance and on a production process, describing it only in the management proposal may mean that the technical evaluators are completely unaware of it or its applicability to the production process. Your proposal may fail to receive credit for your innovation. Or you may have to amend your proposal during the negotiation process so that the

"The three most important parts of any RFP that are essential to understanding the process applicable to any competitive acquisition are Sections L and M and the Statement of Work."

technical evaluators have a clear understanding of your complete strategy. If there are page limits and restrictions on proposal amendment such as we had in USSOCOM's SETA solicitation, this can be a serious oversight.

Not addressing all proposal requirements. It seems to be common sense to address all requirements in your proposal, but this is an egregious and too-frequent proposal error. You must provide whatever information the RFP requests in the specified location and format. If the instructions for your proposal say to address all the issues in paragraph 3.a, specifically address all the issues in paragraph 3.a. If the instructions say to provide a diagram of a

"The most effective and efficient way to respond to solicitations that require distinctly separated kinds of expertise may be to assign parts of the proposals to subcontractors to prepare."

process, provide a diagram of the process. Not doing so immediately provides an advantage to your competitors who can read and follow instructions. Further, it may generate evaluation weaknesses or deficiencies for your proposal that, depending on the specific source selection process, may or may not be recoverable. Before submission do a traceability matrix of Section L requirements against your proposal and make sure everything is there!

Ignoring personnel qualification requirements. Often the government's Statement of Work will specify labor categories and define the personnel qualifications for the labor category. Once a contract is awarded, there is latitude to occasionally waive an educational or other re-

quirement based on an individual's unique experience or other qualifications. However, your proposal is not the place to ignore the requirement for a master's degree and propose the maritime design genius who only has a high school education. It will count against you. Read the education and experience requirements and make sure that the resumes submitted against each category clearly show that the individuals proposed meet these requirements.

DON'T PASS OVERSIGHT ALONG WITH TASKING TO SUBCONTRACTORS

The most effective and efficient way to respond to solicitations that require distinctly separated kinds of expertise may be to assign parts of the proposals to subcontractors to prepare. This could be done easily with the four distinct sample tasks we issued in the SETA-II solicitation. It is especially important with new subcontractors that you do not pass oversight responsibility along with the task. Ensure that as the prime contractor you subject the subcontractor-prepared parts of the proposal to the same rigorous management oversight and "red team" (in-house adversarial review) as the work you retain. If you use groupware for networked proposal development, make the subcontractor use the same system and give you access to it so you can perform progress and reality checks along the way without impeding the process. An unsupervised subcontractor can cripple the proposal of the prime.

PLAN ON WORKING HOLIDAYS

It is not a deliberate plot on the part of the government, but prime time for release

of solicitations for award of operations and maintenance (O&M) funded Contract Advisory and Assistance Services (CAAS) contracts tends to be September through December. This is so contracts can be awarded in the March to June time frame. There is a fiscal year funds flow that makes this optimum. First, the amount of contract funding that is available is not known for certain until the budget is passed (which has no better than a 50-50 chance of occurring by the required October 1 date), and second, it takes time for the government funds distribution process to make these funds available to spend. Because of the budget cycle interruptions, executing new contracts in the October through December period is difficult to accomplish and rarely planned, especially for new services types of contracts. Also, in the DoD O&M funds expire at midnight on September 30, so planning an award in March to June gives the government 4 to 6 months in which to expend the current year funds under contract and get utility from the contract before having to do the administrative contract work to exercise the next year's contract option. This funding cycle never makes for a Merry Christmas for industry.

UNDERSTAND HOW THE EVALUATION WILL WORK

KNOW WHAT'S IN SECTION M

Understanding Section M prevents unpleasant surprises later on and should form the basis for your proposal strategy. Section M always defines the evaluation criteria and the relative importance of the evaluation criteria. Each solicitation has

its own rules within the overall acquisition requirements and regulations and always defines the process and the basis for award in Section M of the Request for Proposal. For example, solicitations often present opportunities to offerors to submit proposal changes to repair deficiencies the government has found during proposal evaluation. This was different in USSOCOM's SETA acquisition. A substantial part of our evaluation rested on the responses to four sample tasks that represented

"The objective of a competitive range determination is to identify proposals that are unlikely to be viable competitors for contract award and remove them from further consideration in the evaluation process."

core support requirements for the command. In order to preclude technical leveling, we did not permit changes to the responses to these tasks and so indicated in Section M of our RFP. Anyone who assumed they'd have a "get well" opportunity for the most important part of the technical/management proposal was wrong.

HOW TO HANDLE MULTIPLE COMPETITIVE RANGE DETERMINATIONS

The objective of a competitive range determination is to identify proposals that are unlikely to be viable competitors for contract award and remove them from further consideration in the evaluation process. Acquisition streamlining guidance suggests progressively decreasing the number of competitors through multiple competitive range determinations at logi-

cal points in the source selection process. If multiple competitive range determinations will be made, Section M of the RFP

"The questions are not intended to 'trip you up' or 'level the playing field,' but to solicit information to ensure a fair and complete evaluation occurs."

will inform industry of the fact and will provide the basis on which offerors will be removed from competition at each determination. Industry

has the right to protest such decisions. Don't protest unless you have an extraordinarily compelling case: although newest guidance says "when in doubt, throw them out," in the early stages of competition the government tends to be conservative in removing contractors from competition: Generally, if there's any doubt, a contractor will be left in. Accept an early cut from the competition and appreciate the fact that it is a way of saving you and the government time, money, and effort that have a significantly high probability of being futile. Protesting your removal from the competition will only run up legal fees, delay the acquisition process, and almost certainly guarantee merely delaying your loss of the competitive award to a later date. In any case, do request a debriefing either at the time you are removed from competition or after final contract award (when data on winning proposals is available) to learn where you were deficient.

STRATEGIZE BASED ON THE EVALUATION CRITERIA

Section M defines proposal evaluation criteria and their relative importance in making the source selection. Naturally an

offeror will want to submit a proposal that receives a high evaluation rating in all areas. But when time gets short, invest your proposal preparation and quality control efforts where they will count most. Except in some special situations (e.g., sealed bid), the government has gone away from the low bid mentality. Generally you will find technical or management approach or a combination being the most important factor in source selection, with cost ranked somewhere lower. As you construct your proposal and red-team it, emphasize the completeness, accuracy, and level of detail in the parts of the proposal that will count most toward source selection. The fact that your proposal is the low-cost proposal is irrelevant if the most important factor is the technical response and your technical proposal is inferior to those of your competitors.

RESPOND FULLY TO GOVERNMENT QUESTIONS

The government may provide questions intended to clarify your proposal or enter into formal discussions with you to permit you to amend your proposal and clear deficiencies. It is important that you respond fully and completely. The objectives of these interchanges are to allow the evaluators to fully understand your proposal and to allow the government to have a choice among fully qualified offerors. The questions are not intended to "trip you up" or "level the playing field," but to solicit information to ensure a fair and complete evaluation occurs.

GIVE YOURSELF FLEXIBILITY IN ORAL PROPOSALS

Carefully read the rules pertaining to oral presentations in sections L and M; understand how the orals will work; pre-

pare for oral presentations at the detail level; but, provide the government higher level advance information. This will give you some flexibility, even under a "no amendment" situation. In USSOCOM's SETA acquisition we required submission of hard copies of slides to be used in the oral presentations as part of proposals and offered the option of also submitting bulleted talking notes. The intention was to prepare the evaluators by giving them an opportunity to understand the general gist of the proposal before actually hearing it presented. However, some submissions were in such great detail that they virtually constituted a written proposal. These proposals locked themselves in. Since no amendment to orally presented sample tasks was permitted, the government could not accept corrections or updates in the presentation or in response to questions and answers. For example, if your advance slide said "300-person database of qualified technical personnel" and by the time of the oral presentations you had expanded it to a database of more than 1,000 qualified technical personnel,

changing the number would constitute unacceptable amendment. However had the slide and notes said "large personnel resource database" you could have explained in your presentation that the database had applications from 1,000 people.

CONCLUSION

A large number of businesses can provide government CAAS support services, so there is serious competition for these contracts. The acquisition process is designed to support an informed selection from competent, qualified competitors. Simple oversights and misunderstandings can handicap an otherwise acceptable proposal. Red teams or other internal reviews can be used to ensure a complete, thorough, and properly focused proposal is submitted. Acting with an understanding of acquisition process for each acquisition and complying fully with proposal instructions will enhance a company's ability to compete.

ESTIMATING THE HEALTH HAZARD COSTS OF ARMY MATERIEL: A METHOD FOR HELPING PROGRAM MANAGERS MAKE INFORMED HEALTH RISK DECISIONS

Gary M. Bratt, Donna M. Doganiero, Clark O. Spencer

We have developed a model to assist the U.S. Army estimate weapon system health hazard costs based on the probability of a hazard occurring and the severity of that hazard. We linked health hazard categories to types of clinic services that might be required as a result of exposure to a specific health hazard; and diagnostic categories based on the potential medical effects that could occur as a result of exposure to a specific health hazard. We researched incidence rates and calculated costs based on industry-wide data on injuries, lost time, hospitalization, and disability, and this framework provides a method to reasonably estimate the medical and lost military manpower costs of unabated health hazards associated with Army materiel. Using the outputs of the model will increase the effectiveness of health risk assessment and management, and better enable the Army to eliminate or control materiel health hazards and control life-cycle costs. Application of this model to other prevention disciplines in acquisition and preventive medicine will provide decision makers with invaluable quantitative information regarding cost avoidance.

U.S. Army medical personnel currently conduct health hazard assessments of new or improved materiel. They assess the types of hazards that exist; the injuries or illnesses likely to result from them; the level of health risk for each hazard; and the corrective actions

needed to eliminate or abate the hazard. Health hazard assessment reports provide this information to the materiel program managers.

We have developed a framework for a medical cost avoidance model (MCAM) that provides a method to quantify reason-

able estimates of the medical and lost time costs associated with unabated Army materiel health hazards. Use of the model will increase the effectiveness of health risk assessment and management.

It seems intuitive that health hazard intervention and prevention activities should significantly ease the burden on the health care system by reducing deaths, disabilities, lost time away from the work site, hospitalization, clinical medical costs, injuries and illnesses, and rehabilitation costs. For years, however, the preventive medicine community has needed a way to estimate the costs avoided—a critical step in the prevention process. Given the cost-conscious environment in which program managers make their decisions, the need to quantify health hazard costs is essential.

We developed this, the first version of the MCAM, specifically to help the U.S.

Army estimate the health hazard costs of materiel systems. It quantifies these costs based on the probability of a hazard and its severity. We linked health hazard categories to potential types of clinic services that might be required as a result of exposure to a specific health hazard, and diagnostic categories based on the potential medical effects that could occur as a result of exposure to a specific health hazard. We then used this information to determine incidence, distribution, and other rates for injury, clinic visits, hospitalization, lost time, disability, rehabilitation, and death. The result is a model that quantifies expected costs of a health hazard. This model better describes a stated health risk, associated lost military manpower, and monetary impact if no preventive or corrective actions occur. We do not address other technical or programmatic risks that materiel program managers must face.

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We are presenting the model to stimulate thought and feedback; it can and should be further refined. Based on our model, Army health hazard assessment reports have recently begun to include the medical costs for injuries or illnesses that will result from the hazards. This information allows materiel program managers to understand the medical costs associated with their systems, and in turn make informed tradeoff decisions concerning corrective actions. The model is currently available as a personal computer-based tool that can perform cost calculations based on user input.

As use of the MCAM continues to increase, and follow-up data become available, we can develop more accurate cost distribution factors, resulting in more accurate forecasts of health costs.

HEALTH HAZARD ASSESSMENTS

The Army performs health hazard assessments in all phases of the acquisition process. Eliminating or controlling hazards early in the process will reduce abatement costs. The Army assesses materiel health hazards using a risk assessment code (RAC) matrix that is defined in Army Regulation 40-10, "Health Hazard Assessment Program in Support of the Army Materiel Acquisition Decision Process," Oct. 1, 1991. This matrix is similar to the ones described in Army Regulation 385-16, "System Safety Engineering and Management," Field Manual 101-5, "Staff Organization and Operations," and Department of Defense (DoD) Instruction 6055.1, "DoD Occupational Safety and Health Program." DoD has been using this

risk-based method to prioritize installation safety and health hazards for abatement since the early 1980s.

ASSESSING HEALTH RISK

Risk per se is a probability statement. The term "health risk," however, combines the severity of a hazard's potential consequences and probability of exposure to the hazard.

Before assigning a health risk to a particular piece of equipment or materiel system, Army evaluators first determine the potential hazards operators face. In their evaluation they also consider existing control measures to minimize exposure to the hazards. Next, they assign each hazard a relative level of risk. The model we present here incorporates the DoD method for assigning "health risk," which combines a hazard's severity and probability. Hazard severity is a relative score that reflects the magnitude of exposure to physical, chemical, or biological hazards and the severity of the medical effects caused by exposure to the hazard. Hazard probability is a relative score that reflects the duration of the exposure and the number of people per system exposed to the hazard. The hazard severity and hazard probability categories are shown in Table 1.

The risk assessment code resulting from the combination of these two components can range from 1 (very high health risk) to 5 (very low health risk). For example, a hazard of marginal severity (hazard severity = III) with an exposure assessed as probable (hazard probability = B) has a moderate overall risk (RAC = 3).

MEASURING COSTS

To quantify the two components of this risk assessment score, hazard severity (S_k) and hazard probability (P_e), for use as cost drivers in our model, we developed a value for each severity and probability category based on the subjective interpretation of the written category descriptions in the regulations. These values are shown in Table 1 in parentheses.

To measure total medical costs for a particular system, assessors must know the number of systems (N_s) that will be procured or are in the inventory and the number of soldiers or crew size per system (N_{ps}). Because the Army uses this matrix for determining system health risk, our intent was to quantify the costs associated with each RAC. Table 1 presents, for a hazard in a sample system—the number of systems (N_s) = 7400 and the number of soldiers per system (N_{ps}) = 4.—the total costs the Army will incur as a result of not abating the hazard for each RAC in the matrix. For example, we can see that

if a hazard assessor assigned a hazard severity of I and a hazard probability of A, the resulting RAC 1 relates to a total cost incurred of \$15,088,000 per year. Program managers can make better tradeoff health risk decisions knowing the dollar impact in addition to RACs. Our procedure for calculating cost is the focus of this article.

Often it is not possible to eliminate a health hazard, even by appropriate controls. Even with a controlled hazard there is a health risk. This residual risk is what remains after controlling a health hazard. One can determine avoided costs by subtracting the residual cost of a hazard from its unabated cost. For example, with a hazard assigned a hazard severity of I and a hazard probability of A, the resulting RAC 1 relates to a total cost incurred of \$15,088,000 per year. If design changes result in a hazard severity of III and a hazard probability of A, the resulting RAC 2 (residual risk) relates to a total cost incurred of \$137,000. The avoided costs therefore are \$15,088,000 minus \$137,000 equals \$14,951,000 per year.

Table 1.
Risk Assessment Codes (RAC) and Costs (Thousands of Dollars) Matrix

Hazard Severity (S_k)	Hazard Probability (P_e)				
	Frequent	Probable	Occasional	Remote	Improbable
	A (.9)	B (.5)	C (.2)	D (.01)	E (.001)
I (1) Catastrophic	1 (\$15,088)	1 (\$8,471)	1 (\$3,508)	2 (\$365)	3 (\$216)
II (.1) Critical	1 (\$1,410)	1 (\$783)	2 (\$313)	3 (\$16)	4 (\$1)
III (.01) Marginal	2 (\$137)	3 (\$76)	3 (\$30)	4 (\$2)	5 (\$0.152)
IV (.001) Negligible	3 (\$13)	5 (\$7)	5 (\$3)	5 (\$0.148)	5 (\$0.015)
Notes: The calculations are based on a high risk system. The numbers 1, 2, 3, 4, and 5, in the columns under Hazard Probability are the RACs. The numbers in parentheses in the columns under Hazard Probability are the medical costs that are incurred for a given RAC if no intervention occurs.					

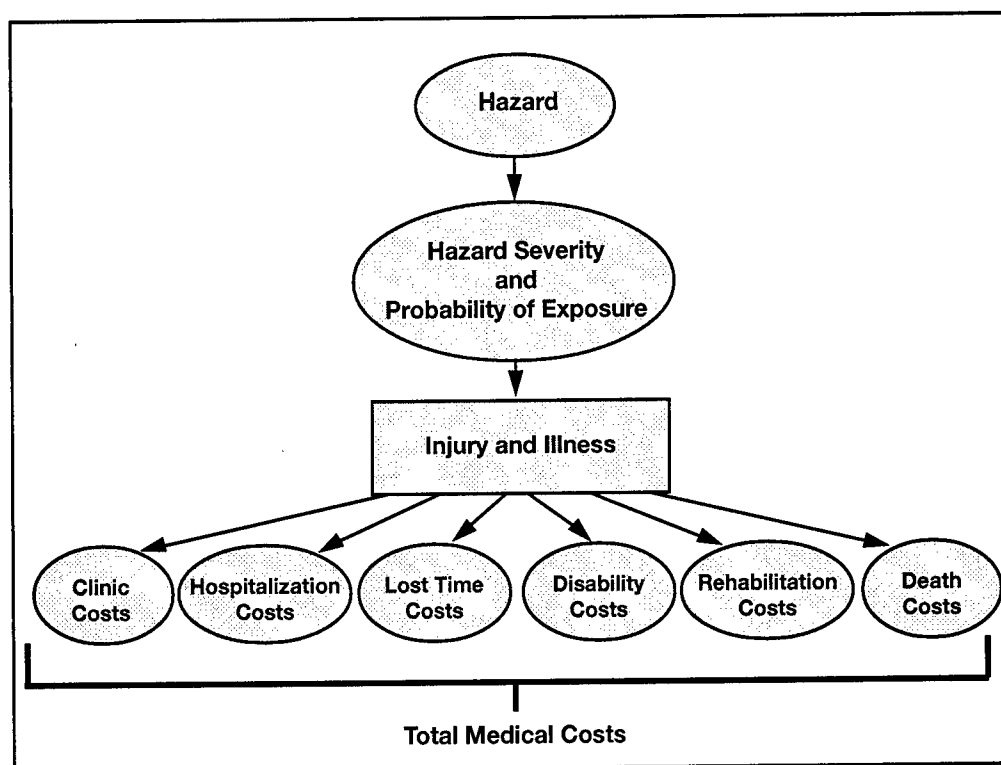


Figure 1. Cost Components for a Single Hazard

METHODS

THE COST MODEL FRAMEWORK

We developed the framework in Figure 1 for determining costs based on six cost components that result from exposure to hazards that cause illness, injury, or death.

Six basic events can occur when a soldier becomes ill or injured. He or she may:

- visit a medical clinic for basic outpatient treatment, medication, and tests (clinic costs, C_c);
- visit a hospital for inpatient observation, emergency or definitive treatment, and more detailed tests (hospitalization costs, C_h);
- lose time away from the job due to clinic and hospital appointments, assignment to quarters, and inability to perform on the job (lost time costs, C_l);
- experience disability, either immediately while on active duty or at a later date after discharge or retirement (disability costs, C_{di});
- require rehabilitation because of disability (rehabilitation costs, C_r); and
- suffer death as a result of exposure severity or complications (death costs, C_{de}).

Because of funding constraints, this initial version of the MCAM did not in-

corporate the costs to acquire and train personnel replacements for those soldiers injured, ill, or killed. We also did not incorporate performance degradation costs or the nonmonetary effect on readiness. Nor did we incorporate the costs related to the impact on family quality of life. These costs could be substantial and should be considered by the system program manager. We recognize that these costs may vary greatly; for example, it costs more to train a pilot than an Infantryman. We believe the system program manager is in the best position to judge the magnitude and impact of these additional costs.

We used industry-wide incidence rates, distribution factors, and other rates for injury, hospitalization, lost time, disability, rehabilitation, and death to quantify health hazard costs for each of the six cost components. The model estimates the total cost per year for exposures to hazards that result in illness, injury, or death, and can be expressed in equation form as follows:

$$\begin{aligned} \text{Hazard costs/year} = & \\ & \text{clinic costs/year} + \text{hospitalization} \\ & \text{costs/year} + \text{lost time costs/year} \\ & + \text{disability costs/year} + \text{rehabili-} \\ & \text{tation costs/year} + \text{death costs/} \\ & \text{year.} \end{aligned}$$

ASSUMPTIONS

We made two primary assumptions: The first was that we could establish the incidence rates—the rate of injury or illness in a group over a period of time—based on historical industry-wide data. Second, we assumed that a medical assessor conducted the risk assessment properly.

We developed incidence rates from comparable industry-wide data that were available during model development, because not all the required data were available or accessible via military sources. This required that we extrapolate from private industry data and relate it to military systems. The risk assessment codes used in this article were determined by experienced health hazard assessors. The assignment of a RAC, with its associated hazard probability and hazard severity, is the critical element in communicating health risk to program managers. Incorrect assessments may result in inaccurate cost modeling.

HAZARD SEVERITY AND HAZARD PROBABILITY

Because we could not use the severity and probability categories in their descriptive form, we developed numerical values for them. These hazard severity (S_k) and hazard probability (P_e) values were key factors in using the model and provided for a range of medical cost and outcome values. We obtained consensus on the values from practicing health hazard assessment experts from the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM).

HEALTH HAZARD LINK

Next, we linked each of the nine health hazard categories (Figure 2) to potential types of clinic services that might be required as a result of exposure to a specific health hazard; and diagnostic categories based on the potential medical effects that could occur as a result of exposure to a specific health hazard. We obtained data on the types of clinic services from the *Federal Register*, and hospitalization, lost time, and disability diagnostic data from

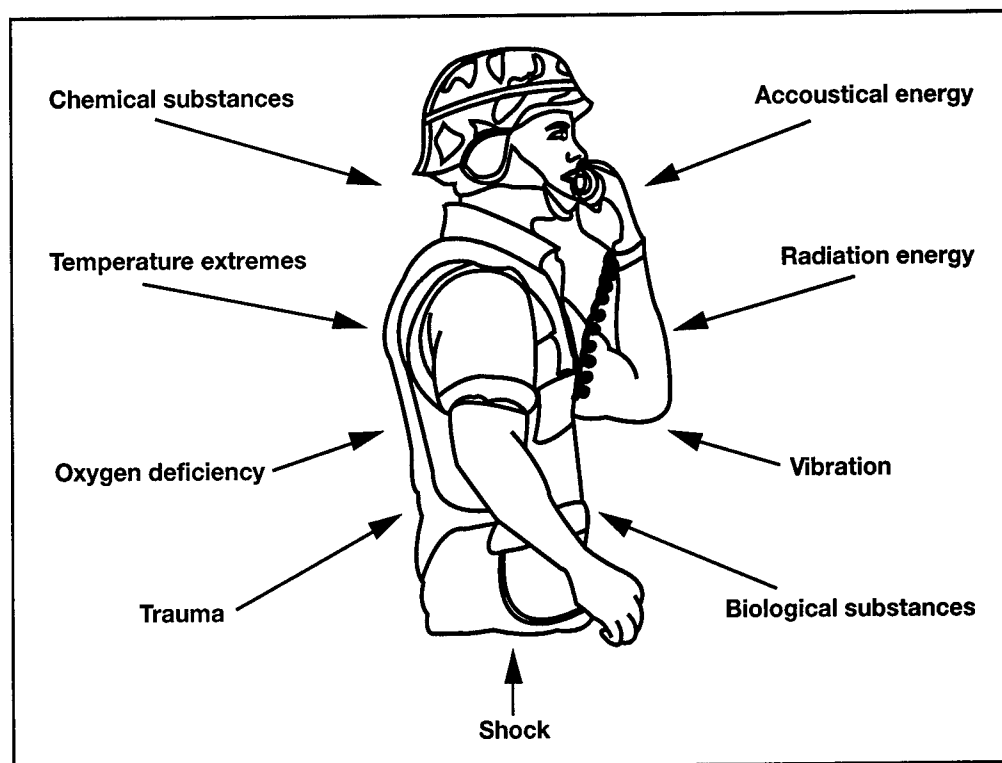


Figure 2.

Army Health Hazard Categories Encountered with Army Materiel

the Army, the Department of Labor, and the Department of Veterans Affairs, respectively.

There are nine Army health hazard categories. Exposure to an individual hazard in one of these categories can result in a variety of injury and illness. The classification (coding) of injury and illness varies. This is because almost every national data collection agency codes injury or illness descriptions differently. For example, the data we used classified:

- hospitalization medical diagnoses using the *International Classification of Disease* (9th revision) (ICD-9) diagnosis categories;
 - lost time diagnoses using the Bureau of Labor Statistics Occupational Injury and Illness Classification System; and
 - disability diagnoses using the Department of Veterans Affairs Disability Classification System.
- An exposure to a chemical substance health hazard could result in a:
- visit to an "emergency care" clinic;
 - hospitalization diagnosis of disease of the respiratory system;
 - lost time diagnosis of exposure to caustic, noxious, or allergic substances; and

- disability diagnosis affecting the lungs and pleura.

While these diagnostic category classifications may not be comparable between data sets; this did not present a problem in determining medical costs, because we calculate costs using the appropriate data set for each cost component.

RISK LEVEL LINK

We then correlated the industry categories of high, medium, and low health risk with Army system categories. This would allow us to use representative industry data for evaluating materiel health hazards.

We used 1993 data from the Bureau of Labor Statistics representative of the range of illness and injury rates within the Army. We selected industries with a high, medium, and low incidence of illness and injury. For example:

- The construction industry represents high health-risk occupations (12.2 injuries or illnesses per 100 full-time workers per year).
- The transportation industry represents occupations with medium health risk (9.5 injuries or illnesses per 100 full-time workers per year).
- The service industry represents occupations with low health risk (6.7 injuries or illnesses per 100 full-time workers per year).

We analyzed each of the categories of military systems to determine the appropriate industry illness and injury incidence rate to apply to each system category. We based our analysis on limited Army illness

and injury data and the experience of a group of senior medical health risk assessors who had worked with these systems. Table 2 shows the correlation between the system categories, industry categories, and incidence (health risk) levels—high, medium, or low—we used to estimate the model component costs.

DETERMINING COSTS

We developed equations for estimating costs that incorporated hazard severity and probability of exposure to the hazard (Table 3). Table 4 provides the equation variables and their values along with a brief description. The equations include costs per year for clinic services, hospitalization, lost time, disability, rehabilitation, and death.

We used industry-wide incidence rates, distribution factors, and other rates for injury, lost time, hospitalization, disability, rehabilitation, and death to quantify health hazard costs based on the six cost components—our model framework—to estimate the costs of exposure to hazards. Below we describe the calculation of each of the cost components:

Clinic costs (C_c). Our primary source of illness and injury data was the *U.S. Department of Labor Bureau of Labor Statistics Survey on U.S. Occupational Injuries and Illnesses for 1993*, December 1994. We selected incidence of illness and injury data from the Bureau of Labor Statistics data representative of the range of illness and injury rates within the Army. We selected the industry categories with a high, medium, and low incidence of illness and injury as previously discussed.

We analyzed each of the categories of materiel systems to determine the appropriate illness and injury incidence rate (I_i)

Table 2.
Correspondence of Risk Levels for Industries and Materiel Systems

System category	Industry category	Assigned risk level
Armored fighting vehicles	Construction	High
Engineer and logistics equipment	Construction	High
Missile artillery	Construction	High
Tube artillery	Construction	High
Air defense systems	Transportation	Medium
Aircraft technology and armament	Transportation	Medium
Ground antitank weapons	Transportation	Medium
Infantry weapons	Transportation	Medium
Other	Transportation	Medium
Smokes and obscurants	Transportation	Medium
Chemical defense equipment	Service	Low
Clothing and individual equipment	Service	Low
Communications, command, and control	Service	Low
Surveillance, fire control, and electronic warfare	Service	Low
Training devices	Service	Low

to apply to each system category. Additionally, we queried historical health hazard assessment data to determine the number of hazards and their RACs for each system category. We rank ordered the system categories using a RAC weighted comparison technique. We based our analysis on limited Army illness and injury data and the experience of a group of senior medical health risk assessors who had worked with these systems. The selected incidence (health risk) levels—high, medium, or low—are used to estimate the model component costs. These values are listed in Table 5.

We developed the values for the number of clinic visits (N_i) by injured or ill soldiers based on the seriousness of the medical effects that could occur. As the severity of the medical effects increases the number of clinic visits would be expected to increase. We subjectively deter-

mined the values based on a consensus of internal and external panel of subject matter experts. The values we selected for each hazard severity category are listed in Table 6.

Hospitalization costs (C_h). Our primary sources for hospitalization data were the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) *Medical Surveillance Monthly Report*, April 1995, and "CHAMPUS DRG Weights for Fiscal Year 1996" published in the *Federal Register*.

We correlated selected classifications of illness or injury diagnoses with the categories of health hazards, as previously discussed. We considered these data representative of the range of hospitalization rates within the Army for hazards associated with weapon systems. We then calculated incidences of hospitalization (I_h)

Table 3. Cost Component Equations

Related Cost Component	Component calculation	Equation
All (except death costs)	Number of people exposed to hazard	$N_e = P_e \times N_s \times N_{ps}$
Clinic costs	Number of people injured or ill	$N_i = N_e \times S_k \times I_i$
Clinic costs	Clinic costs	$C_c = N_v \times F_c$
Clinic costs	Number of clinic visits	$N_v = N_e \times S_k \times [V_e + (I_i \times N_c)]$
Hospitalization costs	Hospitalization costs	$C_h = N_h \times F_h$
Hospitalization costs	Number of persons hospitalized	$N_{ph} = N_e \times S_k \times I_h$
Hospitalization costs	Number of hospital days	$N_h = N_e \times S_k \times I_h \times \sum (D_{hd} \times D_{ho})$
Lost time costs	Lost time costs	$C_l = N_l \times W_d \times B_f$
Lost time costs	Number of persons losing time	$N_{pl} = N_e \times S_k \times I_l$
Lost time costs	Number of lost workdays	$N_l = N_e \times S_k \times I_h \times \sum (D_{ld} \times D_{lt})$
Disability costs	Disability costs	$C_{di} = N_e \times S_k \times I_v \times T_v \times \sum (D_v \times B_v) \times 12 \text{ mo/yr} + [(I_t \times B_t) + (I_p \times B_p)]$
Disability costs	Number of persons disabled	$N_{pd} = N_e \times S_k \times (T_v \times I_v + I_t + I_p)$
Rehabilitation costs	Rehabilitation costs	$C_r = N_e \times S_k \times I_v \times T_v \times \sum D_r \times Q_r \times B_r$
Rehabilitation costs	Number of rehabilitation cases	$N_r = N_e \times S_k \times I_v \times T_v \times \sum D_r \times Q_r$
Death costs	Death costs	$C_{de} = (N_{de} \times B_{de})$
Note: Number of people exposed to hazard ($N_e = P_e \times N_s \times N_{ps}$) is a common term related to all cost components except death costs.		

Table 4. Equation Variables

Related cost component	Equation variable	Variable value	Description
All (except death costs)	P_e	See Table 1	Hazard Probability (HP) - Probability of exposure per year, based on the determined hazard probability category
All (except death costs)	S_k	See Table 1	Hazard Severity (HS) factor based on the determined hazard severity category
All (except death costs)	N_s	No. of systems	Number of systems, the total number individual items of materiel, equipment, or weapon systems in Army inventory
All (except death costs)	N_{ps}	No. of persons	Number of persons per system, or crew size for system, or item
All (except death costs)	N_e	Calculated	Total number of people exposed to hazard per year for the systems or items
Clinic costs	C_c	Calculated	Cost of clinic visits
Clinic costs	N_i	Calculated	Number of people injured or ill
Clinic costs	N_v	Calculated	Number of clinic visits
Clinic costs	V_e	0.75	Visit constant as result of exposure. The visit constant (V_e) equals 0.75 and is based on exposure to a health hazard that results in illness or injury. We assumed that if an exposure event occurs, then 75 percent of all persons exposed to the hazard will visit the clinic for an examination to determine whether any injury has occurred.
Clinic costs	I_i	See Table 5	Incidence of injury or illness based on the determined risk level for the individual item of materiel
Clinic costs	N_c	See Table 6	Number of visits by injured or ill personnel based on the determined hazard severity category. The hazard severity category determines the seriousness of the medical outcomes that could occur. As the severity increases, the number of clinic visits increases. For this cost component, based on values selected by a panel of experts, we assigned the number of visits based on the hazard severity category and the potential medical outcomes.
Clinic costs	F_c	\$122 per visit	Average fee per clinic visit, based on the average of various types of clinic service visit fees. We found the average fee was \$122 per clinic visit.

Table 4. Equation Variables (continued)

Hospitalization costs	C_h	Calculated	Cost of hospitalization
Hospitalization costs	N_{ph}	Calculated	Number of persons hospitalized
Hospitalization costs	N_h	Calculated	Number of hospital days
Hospitalization costs	I_h	See Table 7	Incidence of hospitalization based on the determined risk level for the individual item of materiel
Hospitalization costs	D_{hd}	See Table 8	Factor for the average number of days in hospital per person based on historical hospital stay distribution
Hospitalization costs	D_{ho}	See Table 9	Factor for the hospitalization population distribution for average number of days in hospital
Hospitalization costs	F_h	\$1,669 per day	Average fee per hospital day. Average cost based on various types of hospital diagnosis-related groups and the classification of the disease. We found the average hospital fee was \$1,669 per day.
Lost time costs	C_l	Calculated	Cost of days of lost time
Lost time costs	N_{pl}	Calculated	Number of persons losing time
Lost time costs	N_l	Calculated	Number of lost workdays
Lost time costs	I_l	See Table 10	Incidence of lost time based on the determined risk level for the individual materiel item
Lost time costs	D_{ld}	See Table 11	Factor for the number of lost workdays per person based on historical lost workday distribution
Lost time costs	D_{lt}	See Table 12	Lost time population distribution based on average lost workday distribution
Lost time costs	W_d	\$53.97 per day	Average wage per day. We based the average wage per day (W_d) on the salaries and numbers of persons drawing that salary for a selected group of personnel. We determined an average wage to be \$53.97 per day.
Lost time costs	B_f	1.41	Wage fringe benefit factor. We assigned the fringe benefit factor (B_f) a value of 1.41. It is a standard factor within the government used for programming personnel budget requirements and is representative of other corporate benefit factors.
Disability costs	C_{di}	Calculated	Cost of disabilities

Table 4. Equation Variables (continued)

Disability costs	N_{pd}	Calculated	Number of persons disabled
Disability costs	I_v	See Table 13	Incidence of VA disability based on the determined risk level for the individual item of materiel, equipment, or weapon system
Disability costs	T_v	0.25	VA disability adjustment factor for delayed disability (5 years/20 years)
Disability costs	D_v	See Table 14	VA disability population factor based on historical rate of disability distribution
Disability costs	B_v	See Table 15	VA disability compensation factor per month per rate of disability
Disability costs	I_t	0.001	Incidence of active-duty temporary disability (1 case/1000 persons)
Disability costs	B_t	\$9,242 per person	Active-duty temporary disability compensation per year
Disability costs	I_p	0.011	Incidence of active-duty permanent disability (11 cases/1000 persons)
Disability costs	B_p	\$12,864 per person	Active duty permanent disability compensation per year
Rehabilitation costs	C_r	Calculated	Cost of rehabilitation
Rehabilitation costs	N_r	Calculated	Number of rehabilitation cases
Rehabilitation costs	D_r	See Table 16	Eligible VA disability population factor based on rate of disability distribution equal to or greater than 20 percent
Rehabilitation costs	Q_r	0.05	VA rehabilitation qualification factor (5 cases/100 persons eligible)
Rehabilitation costs	B_r	\$12,000 per year per person	VA rehabilitation benefit per year per person. We estimated to be \$12,000 per year per person. Rehabilitation benefits may vary per person, but we considered \$12,000 to be a reasonable estimate. Other benefits may be available for eligible disabled persons, but we did not consider these other benefits.
Death costs	C_{de}	Calculated	Cost of death
Death costs	N_{de}	See Table 17	Number of deaths per year
Death costs	B_{de}	\$200,000	Death benefit and expenses

Table 5. Incidence of Illness or Injury (I_i) for System Risk Categories

System risk category	Incidence rate (I_i)
High	0.122
Medium	0.095
Low	0.067

Table 6. Number of Clinic Visits (N_c) for Hazard Severity Categories

Hazard severity category	Number of clinic visits (N_c)
I	5
II	3
III	2
IV	1

Table 7. Incidence of Hospitalization (I_h) for System Risk Categories

System risk category	Hospitalization rate (I_h)
High	0.013
Medium	0.007
Low	0.0005

Table 8.
Factors for Average Number of Days in Hospital (D_{hd}) (days/person)

Length of stay in hospital	Factor (D_{hd})
<2 days	1.0
2-5 days	3.5
6-30 days	18.0
>30 days	30.0

Table 9. Factors for Hospitalization Population Distribution (D_{ho}) by Length of Stay in Hospital for System Risk Categories

System risk category	Length of stay in hospital			
	<2 days	2-5 days	6-30 days	>30 days
High	0.40	0.35	0.17	0.08
Medium	0.40	0.36	0.18	0.06
Low	0.42	0.37	0.20	0.02

Table 10. Incidence of Lost Time (I_l) for System Risk Categories

System risk category	Lost time rate (I_l)
High	0.055
Medium	0.054
Low	0.028

Table 11. Factors for Average Number of Days of Lost Time (D_{ld}) (days/person)

Number days of lost time	Factor (D_{ld})
<2 days	1.0
2-5 days	3.5
6-30 days	18.0
>30 days	30.0

Table 12. Factors for Lost Time Population Distribution (D_{ll}) by Days of Lost Time for System Risk Categories

System risk category	Lost time			
	<2 days	2-5 days	6-30 days	>30 days
High	0.22	0.30	0.29	0.20
Medium	0.20	0.33	0.31	0.16
Low	0.15	0.43	0.38	0.04

Table 13. Incidence of VA Disability (I_v) for System Risk Categories

System risk category	VA disability factor (I_v)
High	0.032
Medium	0.012
Low	0.00005

Table 14. Factors for Disability Population Distribution (D_v) by Degree of Disability for System Risk Categories

System risk category	Degree of disability			
	10%	20%-50%	60%-90%	100%
High	0.44	0.42	0.10	0.04
Medium	0.44	0.44	0.09	0.03
Low	0.43	0.48	0.08	0.01

from the historical data. We assigned an appropriate incidence of hospitalization to the system categories, just as we did with the incidence of illness and injury. The high- and low-risk category values represent the medium (mean) risk category value plus or minus one standard deviation respectively. The values are listed in Table 7.

We based the factor for the average number of days in the hospital (D_{hd}) on historical hospital length-of-stay data. This approach provides for a future capability to discriminate between hospital stay

times (bed days), and correlates directly with the hospitalization population distribution. For this

"The primary sources for our lost time data are from the Bureau of Labor Statistics."

model component, we determined numerical factors for the four categories of days in the hospital. The category values represent the midpoints of the range of days in each category. The exception is the greater than 30-day category. Because the historical data available only listed the bed days as greater than 30 days, we selected a conservative value of 30 days for this category. The values are listed in Table 8.

We based the factor for the hospitalization population distribution (D_{ho}) on historical data for the percentage of persons hospitalized for four selected hospital length-of-stay distribution categories. This distribution approach, when combined with the factor for the average number of days in the hospital, provides a future capability to discriminate between hospital length of stay categories. For this model component we determined numerical values for the four hospitalization population

distribution factors within each risk category based on the historical data. The high- and low-risk category factors within each length of stay category represent normalized values of the medium (mean) values plus or minus one standard deviation. The system risk categories with their distribution factors are listed in Table 9.

Lost time costs (C_l). The primary sources for our lost time data are from the Bureau of Labor Statistics. These included *Results of Labor Statistics Survey on U.S. Occupational Injuries, Illnesses in 1993* and tabular data on the percentage distribution of nonfatal occupational injuries and illnesses involving days away from work for 1992.

We correlated selected Department of Labor illness or injury categories with the categories of health hazards. We considered the data representative of the range of lost time rates within the Army for hazards associated with materiel systems. We then selected incidence of lost time rates (I_l) from the historical data and the three industry categories previously discussed. We assigned the selected incidence of lost time rates to the system categories, just as we did with the incidence rates for illness and injury and of hospitalization. These values are listed in Table 10.

We based the factor for the average number of days of lost time (D_{ld}) on historical distribution data for lost workdays. This approach provides a future capability to discriminate between selected lost day categories and correlates directly with the lost time population distribution. For this model component we determined numerical values for the four categories of lost time. These factors were determined in the same manner as the hospital factors. The values are listed in Table 11.

We based the factor for lost time population distribution (D_{lt}) on historical data for the percentage of persons losing time for four selected lost workday distribution categories. This distribution approach, when combined with the factor for the average number of days of lost time, provides for a future capability to discriminate between lost workday categories. For this model component, we determined numerical values for the four lost time population distribution factors based on historical data. The high- and low-risk categories within each length of lost time category represent the normalized values of the medium (mean) values plus or minus one standard deviation. The values are listed in Table 12.

Disability costs (C_{di}). The primary source for our VA disability data was the Department of Veterans Affairs, National Center for Veteran Analysis and Statistics, Demographics Division. A report by the Armed Forces Epidemiological Board Injury Prevention and Control Work Group provided information on active-duty temporary and permanent disability.

Disability costs (C_{di}) consist of costs for delayed VA disability and more immediate active-duty disability. Active-duty disability is either temporary or permanent.

We selected the incidence of VA disability (I_v) from reports by the National Center for Veteran Analysis and Statistics involving disability compensation by class of major disability by combined degree. The data were current as of March 1995. We correlated selected classification of illness or injury diagnoses with the categories of health hazards. We considered these data representative of the range of disability rates within the Army for hazards associated with weapon systems. We

then calculated incidence of disability rates from the historical Persian Gulf disability data. The high- and low-risk category levels represent the medium (mean) value plus or minus one standard deviation. Because the value for the low-risk value was a negative number, we selected the range minimum value for the low-risk category. We assigned an appropriate incidence of disability to the system categories, just as we did with the incidence of illness and injury. The values are listed in Table 13.

We selected incidence of active-duty temporary disability (I_t) and incidence of active-duty permanent disability (I_p) from a report by the Armed Forces Epidemiological Board Injury Prevention and Control Work Group on illness and injury. Its report provided basic information on active-duty

temporary and permanent disability compensation. We calculated a temporary disability incidence rate of 1 case per 1,000 persons. This equates to an factor of 0.001. For permanent disability, we calculated an incidence rate of 11 cases per 1,000 persons for a factor of 0.011. We calculated single rates only because of the limited data presented in the report.

The VA disability adjustment factor (T_v) reduces the VA disability population. Eligible veterans may receive VA disability after leaving military service. One would likely see disabilities compensated by the VA only later in the life of a system. We

"The primary source for our VA disability data was the Department of Veterans Affairs, National Center for Veteran Analysis and Statistics, Demographics Division."

assumed that for a system with an operational life of 20 years, eligible veterans would receive VA disabilities at 15 years. This means that we would only expect disabilities during the last 5 years of a system's operational life. This correlates to a factor of 0.25 (5 years/20 years).

We based the disability population distribution factor (D_v) on historical data for the percentage of persons disabled for four

"The primary source of our rehabilitation data was the Department of Veterans Affairs fact sheets. We selected the incidence of VA disability (I_v) from the National Center for Veteran Analysis and Statistics database reports."

selected disability distribution categories. VA establishes disability in 10 percent increments. The four categories allow for the future capability to discriminate between categories of disability costs.

Based on the historical data, we assigned a distribution factor for each risk category. The high- and low-risk category levels represent the normalized values of the medium (mean) values plus or minus one standard deviation. These factors are listed in Table 14.

We based the VA disability compensation (B_v) factor on historical data for selected degree of disability categories. The approach, when combined with the VA disability population distribution factor for degree of disability, provides the future capability to discriminate between categories of disability costs. The values are listed in Table 15.

We based the active-duty temporary disability compensation factor (B_t) and the active-duty permanent disability compen-

sation factor (B_p) on 1990 historical compensation costs for permanent and temporary disability in the three military services. Using this data provides the future capability to discriminate between military and VA disability costs. The calculated values, from the historical data, for B_t and B_p respectively are \$9,242 per person and \$12,864 per person.

Rehabilitation costs (C_r). The primary source of our rehabilitation data was the Department of Veterans Affairs fact sheets. We selected the incidence of VA disability (I_v) from the National Center for Veteran Analysis and Statistics database reports. These values are the same as those listed in Table 13.

As previously discussed, the VA disability adjustment factor (T_v) reduces the VA disability population. Eligible veterans receive VA disability after leaving military service. We calculated a value of 0.25 (5 years/20 years).

We selected the factor for the eligible VA disability population distribution (D_r) based on historical data for the percentage of persons disabled for three selected disability distribution categories. The values in Table 16 are the same as those listed in Table 14 with the exception of the 10 percent category. Eligibility for rehabilitation is limited to people with a disability of 20 percent or more. This distribution approach provides a future capability to discriminate between categories of rehabilitation costs.

We assumed the qualification factor for rehabilitation (Q_r) to be 0.05 (5 cases per 100 persons eligible). We selected this value based on a subjective estimate of the percentage of people who may apply for and be accepted for rehabilitation benefits. The qualification factor selected may be

low; for example, one VA region estimated its acceptance rate for the VA rehabilitation program to be greater than 20 percent. However, we consider the value adequate for use in the MCAM.

Death costs (C_{de}). The primary source of death data was a report by the Armed Forces Epidemiological Board Injury Prevention and Control Work Group and the death benefit paid by the Serviceman's Group Life Insurance.

We assumed that a potential for death existed only in the catastrophic hazard severity category. There were limited reliable sources of data. This is an area requiring further research to refine the MCAM. The report by the Armed Forces Epidemiological Board Injury Prevention and Control Work Group showed that overall there was approximately 1 death per 1,000 clinic visits. This number is based on the assumption that if a death were to occur, program managers would take immediate action to eliminate or reduce the hazard. We used the values in Table 17 to estimate number of deaths (N_{de}).

There is great variability in calculating the cost of a person's death. Values presented in the literature have varied from over \$100,000 to over \$1 million. Our cost of death includes costs paid by insurance policies plus expenses relating to casualty assistance, honor guard, funeral and burial, family, and other related expenses. Serviceman's Group Life Insurance can pay a beneficiary up to \$200,000 for the death of a soldier. Other expenses incurred by the Army can be substantial. As previously discussed, we did not consider training and personnel replacement costs.

RESULTS

We developed a framework and equations with appropriate variables for estimating reasonable costs for unabated health hazards in Army materiel. We developed reasonable cost estimates by quantifying medical costs associated with unabated materiel system health hazards. The model's lost time component identifies personnel time away from the job, an output directly relating to unit readiness and productivity.

AN EXAMPLE COST ESTIMATION

As an example, we estimated costs for an Army system (System X) evaluated by health hazard assessors, for which they wrote a health hazard assessment report. Remember that health hazards are inherent in all U.S. Army materiel systems. If ignored, however, these hazards can cause serious injuries and illnesses to military and civilian operators throughout the life of the system.

In our case, the medical costs for treating those injuries and illnesses can pose significant financial burdens to the Army and Veterans Affairs

health care systems. For example, implementation of recommendations to control health hazards for our example results in avoiding potential medical and lost time costs greater than \$345 million over the life of the system.

System X had 10 health hazards: weapons combustion products, fire extinguish-

"There is great variability in calculating the cost of a person's death. Values presented in the literature have varied from over \$100,000 to over \$1 million."

Table 15. VA Disability Compensation Factors (B_v) by Degree of Disability (dollars/month/person)

Degree of disability	VA disability compensation factor (B_v)
10%	\$91.00
20%–50%	\$340.25
60%–90%	\$915.50
100%	\$1,865.00

Table 16. Eligible VA Disability Population Distribution Factors (D_v) by Degree of Disability for System Risk Categories

System risk category	Degree of disability			
	10%	20%–50%	60%–90%	100%
High	0.0	0.42	0.10	0.04
Medium	0.0	0.44	0.09	0.03
Low	0.0	0.48	0.08	0.01

Table 17. Number of Deaths (N_{de}) for Hazard Severity Categories

Hazard severity category	Number of deaths (N_{de})
I	1
II	0
III	0
IV	0

Table 18. Health Hazards and Associated Risk Indices for System X

Hazard category	Hazard	Risk assessment code (RAC)	Hazard severity category	Hazard probability
Chemical substances	Weapons combustion products	1	I	A
Chemical substances	Fire extinguishing agents	2	II	C
Chemical substances	Carbon dioxide	3	II	D
Acoustical energy	Impulse noise	2	II	C
Acoustical energy	Steady-state noise	2	II	C
Temperature extremes	Cold stress	2	II	C
Temperature extremes	Heat stress	2	II	C
Oxygen deficiency	Oxygen deficiency (ventilation)	2	II	C
Radiation energy	Nonionizing radiation	2	II	C
Radiation energy	Ionizing radiation	4	II	E

Table 19.
Life-Cycle Costs of Several Unabated Health Hazards for System X

Hazards	Costs (Thousands of Dollars)						
	Clinic	Hospital	Lost time	Disability	Rehabilitation	Death	Total
Weapons combustion products	88,402	81,904	27,852	98,173	1,432	4,000	301,763
Nonionizing radiation	1,612	1,820	619	2,182	32	0	6,265
Carbon dioxide	81	91	31	109	2	0	314
Ionizing radiation	8	9	3	11	0	0	31
Six other hazards	9,672	10,920	3,714	13,092	192	0	37,590
Total	99,800	94,700	32,200	113,600	1,700	4,000	346,000
Note: Table totals are rounded to the nearest hundred thousand.							

Table 20. Individual Component Outputs for Selected Hazards for System X—Yearly Basis

Hazard	Component outputs								
	Clinic visits	Persons injured/ill	Persons hospitalized	Hospital days	Persons losing time	Lost work-days	Persons disabled	Rehabilitation cases	Deaths
Weapons combustion products	36,230	3,250	346	2,454	1,465	18,300	533	7	1
Nonionizing radiation	661	72	8	55	33	407	12	0	0
Carbon dioxide	33	4	0	3	2	20	1	0	0
Ionizing radiation	3	0	0	0	0	2	0	0	0
Six other hazards	3,966	432	48	330	198	2,442	72	0	0
Total	40,900	3,800	400	2,800	1,700	21,200	600	7	1
Note: Table totals are rounded.									

ing agents, carbon dioxide, impulse noise, steady-state noise, cold stress, heat stress, oxygen deficiency (ventilation), nonionizing radiation, and ionizing radiation. Table 18 lists the identified health hazards and the risk assessment codes assigned by the health hazard assessors during their evaluation.

We determined the costs incurred over the operational life (20 years) of the system as a result of unabated health hazards. These costs are significant—in this case, greater than \$345 million. Lost time, disability, rehabilitation, and death costs of \$150 million, along with clinic and hos-

"The medical cost data clearly showed that unabated health hazards can have a significant impact on readiness and the health care system over the operational life of our system."

pitalization costs of \$195 million, impact military readiness, productivity and the health care system. Table 19 summarizes the model component life-cycle costs for several

of the 10 unabated health hazards for the system. We calculated costs for one hazard in each risk category. Health hazard intervention can reduce these costs. The application of dollar amounts to the health hazards provides new insight into areas requiring attention concerning materiel acquisition decision making.

Program managers can easily see which health hazards require immediate attention and priority abatement. They can determine whether the magnitude of the costs could have a severe impact on readiness. The avoidance of these costs can make resources available for other use—an im-

portant consideration in our current cost-constrained environment.

The medical cost data clearly showed that unabated health hazards can have a significant impact on readiness and the health care system over the operational life of our system. The individual component outputs give a detailed picture of these impacts. Table 20 summarizes the yearly individual component output data for several of the 10 unabated health hazards. Again, we calculated output data for one hazard in each risk category.

If these hazards are not abated, we can expect to see 3,800 injured or ill soldiers, 1,700 soldiers losing time at work, 600 disabled soldiers, and 400 hospitalized soldiers on a yearly basis. This has a tremendous impact on available manpower. Lost workdays account for a total of 21,200 days per year. Yearly, we can expect 40,900 clinic visits and 2,800 hospital days as a result of exposure to health hazards resulting in illness and injury. This also presents a great burden on the health care system. Health hazard intervention can reduce these costs.

EVALUATION OF MODEL

We assessed the results of the medical cost avoidance model from the perspectives of validity (Did we measure the right things?), reliability (How well can we measure those things?), practicality (Can we make a decision based on the model output?), and sensitivity (What is the impact of the model output to possible errors in the data?). Validity and reliability are relative measures, not absolute. For all of these perspectives, improvements in data collection and source data will improve the MCAM's validity.

VALIDITY

As a first step, the model produces reasonable "real world" results. The components of this model are representative of the basic outcomes that all prevention programs should measure. Most of the data for the model parameters are obtained from actuarial-type databases. While we linked industry categories to Army system categories so that we could use hazard data available for industry, rather than using actual Army data, this substitution does not invalidate the model. Existing Army and industry-wide databases do not relate illnesses and injuries to their "root cause." The degree of validity of the model may increase with the exclusive use of Army data. We did not include some potential indirect costs that could be incurred as a result of illness or injury. We do not believe that this detracts from the utility of the model. For example, some of these costs could include: the costs to acquire and train personnel replacements for those soldiers injured, ill, or killed, performance degradation costs or the nonmonetary effect on military readiness, and the costs related to the impact on family quality of life.

We recognize that these costs could be substantial and should be considered. We also recognize that these costs may vary greatly; for example, it costs more to train a pilot than an infantryman. We believe the system program manager is in the best position to make an assessment of the impact of these additional costs.

RELIABILITY

The MCAM outputs are reliable. Its parameters are measurable or can be estimated. Assuming medical assessors perform risk assessments correctly and con-

sistently, the model will produce the same outputs. Remember that risk assessments are subjective in nature; as assessors become more experienced, then we would expect to see them assign a particular hazard the same hazard severity, hazard probability, and risk assessment code. The data used in this model, while obtained from industry-wide sources, were necessary and adequate to obtain quantitative cost estimates. The data are comprehensive

and reliable. Additionally, these sources already have established collection procedures, update their data annually, and make them available for use. Improved reliability could be achieved by having outpatient and or inpatient medical records provide specific information concerning the "root cause" of an illness or injury. Currently, medical records contain a diagnosis, but do not contain the "root cause." In the future more detailed statements in medical records would improve data reliability. An example of this kind of useful information is: "This hospital visit for more detailed tests was the result of an exposure to a chemical substance from an armored fighting vehicle. It resulted in a respiratory system disease diagnosis by medical personnel."

"The MCAM outputs are reliable. Its parameters are measurable or can be estimated."

PRACTICALITY

The validity and reliability of the MCAM are adequate for its purpose as an initial cost estimating model. Its outputs are also very practical to use, and help explain what a RAC means for health hazards associated with a particular system.

Greater data specificity for hazard and medical diagnosis should improve the understanding of the monetary impact of different hazards with the same RAC. The accuracy of most of the individual measures could be improved, but doing so would require research funding.

SENSITIVITY

The model is most sensitive to the selection for hazard severity and hazard probability (Table 1). Once the matrix cell has been selected using those two factors, the model exhibits the greatest sensitivity to hospital and clinic costs (Tables 20 and 21). Due to differences in the sizes of both hospitals and clinics, these costs can vary significantly. Trying to obtain the "true" hospital and clinic costs would be highly desirable; however, we have minimized extreme cost variations by averaging historical data for many types of hospital and clinical services.

DISCUSSION

We showed that the MCAM will estimate total costs based on the determination of a health risk; if we can quantify a health risk, then we can estimate its costs. USACHPPM's Health Hazard Assessment Office is currently testing an automated version of the cost model. We incorporated the model into their health hazard assessment database, and we developed a project officer module for USACHPPM personnel to use in performing health hazard assessments. Thus these estimated costs are being provided to program managers, but we do not know how they are using this information. This issue requires dedicated follow-up, to de-

termine the efficacy of the model's use and its potential impact.

Using the results of the MCAM can make health risk management more effective. Quantifying health hazard costs improves a program manager's understanding of the monetary impact of not eliminating or mitigating a health hazard. The model's lost time component identifies personnel time away from the job, an output that directly relates to unit readiness and productivity.

The model is based on the events (clinic visits, hospitalization, lost time, disability, rehabilitation, and death) that can be triggered by exposure to the causes of disease and injury. It would therefore be useful for assessing similar hazard intervention in other related programs—system safety, human factors engineering, and preventive medicine.

The bottom line for prevention programs is to reduce the personal, personnel, and health care costs of unabated health hazards. To assess the reduction in medical costs, prevention programs can use the model's component outputs as performance indicators and measures of effectiveness.

OTHER APPLICATIONS

While we developed the MCAM for assessing the health hazards in Army materiel, it has applications that expand into other MANPRINT (Manpower and Personnel Integration) domains that assess health risks.

The model could be used in the following ways:

- System safety engineers and human factors engineers could estimate medical costs for system safety and human

factors engineering hazards of Army materiel.

- Industrial hygienists and occupational health personnel could estimate medical costs for hazards of industrial production line operations.
- Environmental engineers and health risk assessors could estimate medical costs for hazards associated with the cleanup of hazardous waste sites. They could also assess other environmental health hazards from environmental pollution.
- Preventive medicine physicians, environmental science officers, sanitary engineers, and community health nurses could estimate medical outputs for environmental hazards found on the battlefield.

LIMITATIONS OF THE MODEL

There are several limitations to our model:

- We do not include pollution prevention savings in the estimate of medical costs. We consider only potential dollar costs avoided for medical and lost time costs related to the illness or injury caused by exposure to the hazard.
- We do not subtract out the costs of the actual implementation of health hazard assessment recommendations. These costs depend on the type of recommendation made, the degree of reduction of the health hazard, and the life-cycle phase. Costs may include potential publication or labeling, pro-

TECTIVE equipment, production process changes, engineering design, operation and maintenance, retrofitting, and disposal.

- We do not incorporate the costs to acquire and train replacements for personnel injured, ill, or killed. We also do not incorporate the costs of degraded performance or the nonmonetary effect on military readiness. Nor do we incorporate the costs related to the impact on family quality of life. As we previously discussed, these costs could be substantial and can be best addressed by program managers.
- We do not use only military data for estimating costs. In the absence of required relevant military data we extrapolate private industry data and relate them to military systems. We made the assumption that the industry data were relevant and we could develop Army materiel risk categories based on this industry data. We believe the results obtained are reasonable. However, we do encourage readers to research and apply equation variable data appropriate for their particular operation.

We believe that pollution prevention, hazard abatement, and other implementation costs would be minimal compared to system procurement costs, when health hazard assessment recommendations are incorporated during system design.

CONCLUSIONS

The framework we have developed provides a method to quantify reasonable estimates of the medical and lost time costs associated with unabated health hazards associated with Army materiel. Using the outputs of the model would increase the effectiveness of health risk assessment and management.

We have presented the model to stimulate thought and feedback; it can and should be further refined. As its use increases and follow-up data become available, we can develop more accurate cost distribution factors, resulting in more accurate forecasts of health costs.

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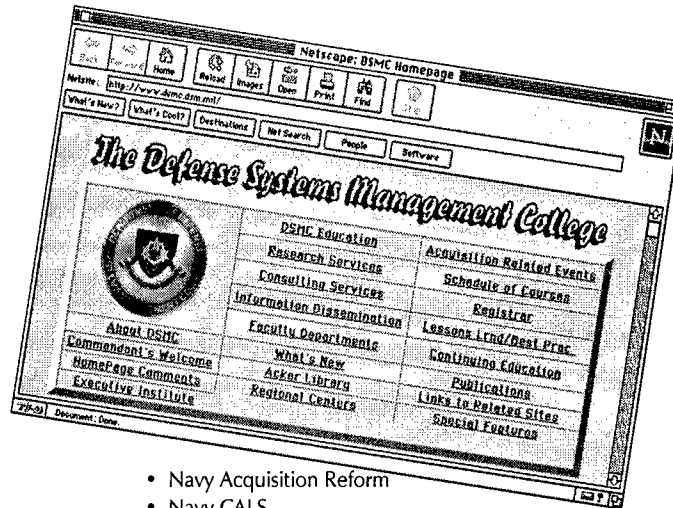
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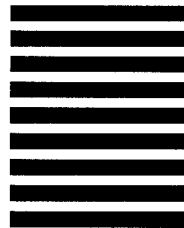
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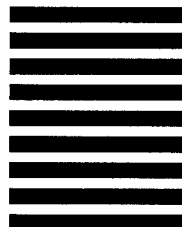
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