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ACQUISITION Review QUARTERLY

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"CYCLE TIME" — A MILITARY IMPERATIVE AS WELL

Dr. Walter B. LaBerge

Dean Clubb, President of the Defense Systems of Electronics Group, Texas Instruments, Inc., makes in his article, beginning on page 175, a reasoned and impassioned plea to DoD to incentivize its defense contractors so that "minimum cycle time" and integrated development can become the primary criteria in defense procurement awards and in performance evaluation. From TI's commercial experience, where he feels the business conditions to be quite similar, Dean extrapolates that Defense Procurement emphasis on "minimum cycle time" and Integrated Product Teams can produce striking improvements for DoD in product quality, significant reduction in product cost, and more rapid new product introduction.

The upper management in the Department of Defense has challenged the acquisition community to reduce cycle time by at least 50% by the year 2000. However, within the bowels of DoD, vested interests (that are responsible for previous piece-part, sequential, non-integrated procurement processes) are now developing antibodies to fight this threat to their survival. Skilled in this survival adaptation, these bureaucratic forces are mutating like their biological viral equivalents into new forms both impervious to these new DoD directives and yet maintaining their ability to impede processes like those proposed by Dean Clubb. The only way to thwart their successful mutation is to inject as many as possible strong white corpuscles into the fray so as to overwhelm them before they mutate. The off-line military defense establishment is giving its all at the blood bank, but so far the fighting military appear not to be active in this needed blood donation campaign.

So far the fighting part of the U.S. military have viewed all this cycle time discussion quite passively, seeing it as part of the endless chain of well-intended attempts by new administrations to do better than their predecessors in the morass of government procurement. So far, the fighting military have not seen Dean Clubb's argument for "minimum cycle time" procurement as the *sine qua non* of their military capability. If the senior fighting military could come to the realization of the absolute criticality of minimum cycle time to their service's survival, then perhaps they could donate their energies and overwhelm the antibodies to change before they develop a strain completely impervious to minimum cycle time.

It is the intent of this short article to try to convince the senior fighting military that minimum cycle time is indeed the next best thing to sliced bread from the fighting man's perspective, and thereby to induce strong intervention within their organizations to assure its wholehearted adoption throughout their services, who in the end execute the predominance of defense procurement.

Military Argument For Minimum Cycle Time Procurement

The reason for strong military endorsement of minimal cycle time is a military, not a financial, one. The figures of merit of minimal cycle time probably are the differences between winning and losing wars, not the savings of 10–15% in procurement costs.

Current lack of understanding of this absolutely critical phenomenon lies in the roots of our past which produced a requirements process responsive to the era of Soviet confrontation. In that era, the United States was threatened by a mortal enemy with sufficient technical ability and resources to provide a broad range of technological improvements to the capabilities of their forces. Because their world of technology and our own were separate, we were poorly equipped to know in which direction they were going, and were therefore obliged to follow all of the directions that we suspected that they might follow.

In that era, the overwhelming Soviet threat to our national interests forced us to implement a requirements process that was based on a threat model of an unknown but competent isolated enemy. The urgency of that perceived threat obligated us to counter with an extremely broad-based program of product introduction, no matter what the impact to the U.S. economy.

Today, things are quite different. The threat today is much more sinister, because it is for the most part *optional*. The United States today has no equivalent of the former Soviet threat in Central Europe on which to base all its action, nor is it probable that there will be an equivalent of the attack on Pearl Harbor, which in 1941 precipitated us involuntarily into war with a major power.

Our military intervention in the next decade will necessarily have to be "one–off" individual decisions made by the President and the Congress based on their view of the importance of such intervention compared to the threat to the lives of American personnel involved. Also, today

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our financial situation is quite different from that of the years of the Reagan military buildup. We probably will never again in our productive lives see the procurement budgets of those now bygone years.

Worse yet, no longer are we contending with an industrially isolated state from whom our technology advantages could be deprived until they appeared in the field. Now, anything we intend to have in advanced military technology is in no time available to everyone else who hears of our interest. This technology is available from friend or enemy, through third parties privy to our best technology. The product applications that were previously unavailable to our enemies now is instantly available to anyone who wants it. It used to take our former Soviet enemies quite a long time to develop weapons by themselves. Now these secrets can be obtained far more quickly from our friends using technology shared by the multi-country industrial consortia around the world. Everyone—ourselves and our enemies—can and do react quickly to technological changes.

One way to look at the threat to our military forces today is that at least for several decades there will be no long-term threat and that the short-term threat cannot be defined. The threat will be different from every one of our enemies, and the threat we hold for each of them will vary depending on how we attempt to posture ourselves.

In our open post-Cold War society our potential enemies can see what we are doing to improve our military capability, and they can straightforwardly be expected to change directions to thwart us. (An example might be the upgunning we now contemplate in any future U.S. Main Battle Tank (FMBT). If we go for a 140mm gun as a main armament, that's the way the enemy can go, delayed only by the time needed to copy the broadly available technology. If an enemy sees us decide on rockets for main armament of an FMBT, then it will either copy that upgrade or procure a defensive system based on the same generation of technology.

The real threat to the defeat of U.S. forces in this era is, to use the commercial terms, potential dominance in product cycle time by our potential enemies. All our enemies need to do is to be able to adapt our current technology to the particular circumstances of their operational environment faster than we can learn what they are up to and respond with improvements that vitiate their actions. If we can't do that, we are probably never going to deploy our forces. And if that happens, U.S. military forces will have been thoroughly *defeated*, although it may never show as such on history's scoreboard.

Our only hope is to be the winner in a "cycle time race," where unfortunately our enemies have the advantage of access through our open society to our technology. Our only hope in this unpredictable new world is to prepare technologically for everything an enemy might decide to do, but because of our uncertainty and financial limitations build very little for the field until we know what is going to be needed, and then to build it *lickety-split*.

Building things *lickety-split* is the *sine qua non* of what Dean Clubb's paper is all about. American industry has for a decade been living in a world of intense competition but at the same time intense technological sharing. In the 1980s we used to get our clocks cleaned in that world, inventing new technology that others could copy and get to the market quicker than we could, even with our head start. Now, however, with Dean's minimum cycle time emphasis, U.S. industry is now beginning to regain product initiative and is winning worldwide product acceptance in the auto, communications, computer, and medical equipment industries.

Dean and Texas Instruments have had no other alternative than to play in the only commercial game available to them. They cannot sit on their hands and continue product strategies that no longer apply. The alternative, changing with the times, is that no one will use their products in the future and that they will go out of business. That is not at all different from the plight of U.S. military today.

The choice for the fighting military is almost equivalents to those of Texas Instruments: Get with minimum cycle time and respond to the marketplace, or get out of business because no one will use your products. What industry calls market research DoD must copy with its intelligence systems, so it can predict correctly what products should go to the marketplace. In periods of curtailed investment in the business world, little is put into the market that the public cannot be expected to need and therefore buy. The same is inevitably the case for defense procurement.

To conclude this companion piece to Dean Clubb's fine article, let this author advise the fighting military that minimum cycle time is of extreme importance to their future, and that the military at the highest levels must actively engage in taking on the reduced cycle time challenge. Our senior military must fight any bureaucracy that appears to thwart things crucial to our nation's defense. Bureaucracies are hard to change. They survive because they can mutate with amazing alacrity. Unless the senior fighting military are willing to give their blood to this worthy cause, they may see their own bureaucracy defeat a concept of the greatest importance to their future.

THE SYSTEM ARCHITECT ROLE IN ACQUISITION PROGRAM INTEGRATED PRODUCT TEAMS

Ronald R. Luman and Professor Richard S. Scotti

The appointment of overall system architects for Department of Defense (DoD) acquisition programs, preferably as leaders of Integrated Product Teams, would ensure design flexibility, provide for rapid insertion of advanced technology, enhance system functionality, and make more effective tradeoffs between cost and performance. It is especially critical in developing weapons or other systems that must be integrated into an existing system of systems to achieve an enhanced synergistic effect. This approach also facilitates development processes for current and future user needs, consideration of a full range of design alternatives, and testing throughout the full operational envelope.

America's military–industrial complex evolved over five decades to support the defense needs of a nation engaged in a Cold War. With the end of that war, government and industry have been forced to reorient their strategies, priorities, overall industrial base, and weapon systems to meet the military requirements of a "Hot Peace." Complicating their efforts, the American public remains wary of distant low-intensity conflicts and exhibits little tolerance for American casualties. Also, Congress increasingly sees the Pentagon as an obstacle astride its path to a balanced budget. These concerns demonstrate the need to develop and field advanced technologies to increase America's warfighting effectiveness and ultimately minimize the number of American combat casualties.

Indeed, the program manager faces new and complex challenges for systems acquisition: to accelerate the development cycle, deliver affordable systems, and minimize risks by integrating new technology when it arises. Not surprisingly, the challenges of *faster, cheaper, and better!* do not always nicely dovetail. Integration of existing, readily available components into "new" systems is being encouraged by industry, but at a price. Many defense firms are now shortchanging long-term technology research to invest in prototypes or system components they hope will meet some immediate military requirement. A barrage of information about commercial-off-the-shelf (COTS) components or nondevelopment items (NDI) bombards the decision maker every day. Program managers, sorting through these "solutions" developed with private sector dollars, attempt to formulate an optimal combination that will meet their needs in the most cost-effective manner.

Acquisition reform is under way to meet these challenges while leveraging industry investment. Government attempts at accelerating the usual acquisition cycle include such innovative and complementary measures as the Advanced Technology Demonstrations (ATDs) and the Advanced Capability Technology Demonstrations (ACTDs); often described, respectively, as "technology pushes" and "military need pulls" (Lynn, 1994). Although these initiatives promote the quick fielding of new, militarily useful technologies, they also operate outside of the normal acquisition process and have not yet addressed the issue of effectively transitioning these advanced technologies into either category of large, on-going weapons procurement programs or the many existing, complex "systems of systems" that support entire warfare areas (Eisner, 1991, 1993).

Compounding this, the private sector's investment in staff, facilities, and technology for research is increasingly restricted to the perceived niche markets of each firm. Today's potential system developers are more apt than not to identify problems that can be accommodated by those solutions that are already on their shelves or technologies integral to their own Independent Research and Development (IRAD) investments when peering through this lens. Although well-intentioned, the resulting products are usually marketed as advanced technology insertion to complex systems of systems—without due regard for the appropriate system of systems architecture.

A program manager can cope or even thrive in this new environment by using the system architect to achieve a level of design flexibility that will allow for the rapid insertion of advanced technology, and also enhance system functionality and performance. The system architect is independent of the developer or contractor, and is well-positioned to monitor the marginal utility of the new or upgraded system as it relates to the effectiveness of any larger "system of systems." Other benefits of this approach include the facilitation of (a) development processes for both current and future user needs, (b) consideration of a full range of design alternatives, and (c) representative testing throughout the full operational envelope to ensure low risk.

A system architect naturally complements the system developer, much like the commercial architect complements a builder. The system architect concept also fits naturally into the Integrated Product Team approach directed by the Under Secretary of Defense (Acquisition and Technology) as a key tenet of acquisition re-

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form (Under Secretary of Defense, 1995; Secretary of Defense, 1995). Further implementing guidance regarding IPT structures (USD[AT] and ASD[C³I], 1995) suggests that the "Integrating IPT" chairman functions as the system architect. To understand the role of the system architect and its potential for accelerating the acquisition cycle and advanced technology insertion, it is necessary to review the current DoD system engineering process.

Review of the Systems Engineering Process

The discipline of systems engineering is an integral element of DoD acquisition. Although the DoD initiative to adopt the best commercial practices has resulted in cancellation of the old MIL-STD-499 (1974) on systems engineering, its intended successor (MIL-STD-499B, 1994) has been converted to a commercial standard, EIA/IS-632 (1994). Managers of major government acquisition programs are required to take the five-month Defense Systems Management College (DSMC) systems engineering management curriculum at Fort Belvoir, VA (Department of Defense, 1991 and 1995). Systems engineering will remain as the foundation of acquisition and development, lending standardized quality to the process, and providing

> ... a comprehensive, structured, and disciplined approach for all life-cycle phases, including new system product and process developments, upgrades, modifications, and engineering efforts conducted to resolve problems in fielded systems. (EIA/IS-632, 1994, p. 1)

The basic systems engineering process contains four activities, applied iteratively as illustrated in Figure 1 (reproduced from MIL-STD-499B, 1994, nearly identical to that in EIA/IS-632): requirements analysis, functional analysis/allocation, synthesis, and systems analysis and control. This process is generally executed by agreement between two parties: the tasking activity as the organization requiring the technical effort (i.e., program manager), and the performing activity as the organization doing the technical effort (e.g., system developer or prime contractor).

Systems Engineering Process Input

Generating and assembling the information necessary to effectively develop a system is an iterative process. In theory the tasking activity provides the performing activity with all the information relevant to its needs, objectives, requirements, measures of effectiveness (MOEs), operating environment, constraints, etc. It then directs the performing activity to consolidate this information for the government's review and approval during the requirements analysis phase. Obviously, the systems engineering process requires sufficient detail for a system developer to generate a realistic proposal. However, it is no exaggeration to say that the government's initial statement of mission need, for example, can consist of a one-sentence statement. Hence the generation of a comprehensive set of the necessary inputs is an iterative process involving both the tasking activity and the potential developers themselves.

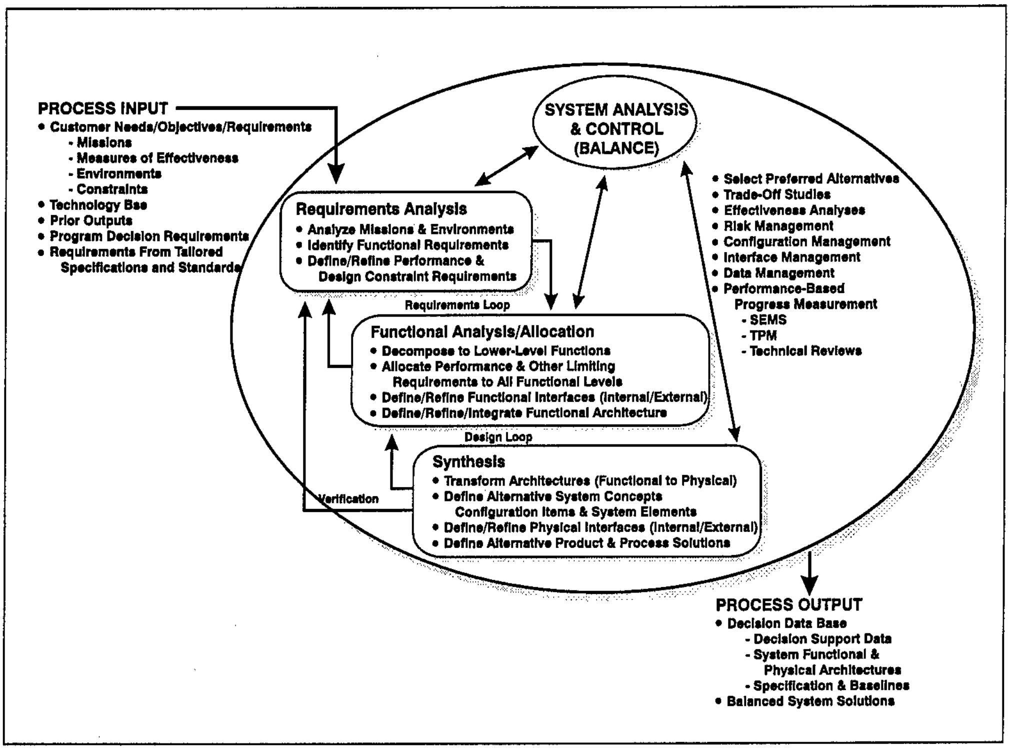

Figure 1. The Systems Engineering Process

The system architect should be a key player in this first phase of system development as part of the tasking activity, offering both systems engineering and program management perspectives. Discipline is required to avoid a natural tendency to solve the problem before it is fully formulated (i.e., premature movement to particular solutions must be resisted in the interest of solving the correct problem).

REQUIREMENTS ANALYSIS

The primary outputs of this phase are the overall functional architecture and associated performance requirements that have been built on MOEs provided or approved by the sponsor. As noted above, MOEs are often not known by the sponsor at the level of detail necessary to determine even overall requirements, and must be developed with full consideration given to mission need, operating environment, achievable technology, and sponsor objectives and constraints. This effort requires expertise in a range of disciplines, from concepts of operation through state-of-the-art technology, and, increasingly, a knowledge of the performance and robustness of available commercial systems as well. Requirements analysis is conducted iteratively with Functional Analysis/Allocation to ensure that the system's objectives are achieved within the limits of available technology and resources.

Moreover, system performance requirements "shall consider the full life cycle envisioned and must be characterized in terms of degree of certainty in their estimate, the degree of criticality to system success, and their relationship to other requirements, in order to facilitate prioritization of requirements during trade studies and/or final evaluation of alternatives and selection of the system design" (DoD, 1991). Considerable controversy exists as to the degree of flexibility with which "requirements" are to be treated, with design-to-cost approaches requiring maximum possible flexibility.

Functional Analysis and Allocation

In this phase, the system's functional architecture is developed in detail sufficient to support a synthesis of alternatives. The overall functional architecture is analyzed and logically sequenced, with inputs, outputs, and interface requirements clearly defined. Levels of performance are either assigned or derived for each functional requirement and interface so that overall performance requirements may be traced throughout the functional architecture. This division and allocation is continued until the resulting set of requirements is defined in quantifiable technical performance measures (TPMs) or go/no-go criteria, as appropriate, and in sufficient detail to be used as design criteria.

Functional analysis and allocation generally does not have one "right" solution, and "optimal" is hard to define, let alone achieve. Hence this phase requires the exercise of judgment when initially allocating performance requirements to functional elements. Moreover, flexibility must be maintained to allow the different approaches arising in this phase of development to be considered and costed out by each subsystem activity during the subsequent synthesis phase. For example, the allocation of an overall budget of accuracy errors for a strategic missile system across such subsystem activities as initial conditions, in-flight guidance, re-entry body deployment, geodesy, and re-entry flight dynamics will require an understanding of the disparate technologies and costs associated with maximizing subsystem performance. Successes and failures at innovation must also be accommodated through an iterative process that can reach all the way back to requirements analysis. Of course, it gets harder to adjust performance (especially in functional allocations) as the development cycle progresses. Not only is it more costly to accommodate design changes, but the system developer grows increasingly reluctant to consider changes affecting its own costs (and profits), even when it may be clear that the system would better meet mission objectives were changes made.

Synthesis

Synthesis is that phase of development in which complete alternative system designs are generated in an iterative fashion with functional analysis and allocation. Synthesized designs will describe the entire system, including the interfaces between internal subsystems or components and the external environment. The system designer must verify that alternatives will satisfy functional and performance requirements and that they are attainable within estimated risk levels.

As previously discussed, there is currently pressure to find ways of using COTS components or technology. A COTS solution may appear to be so simple that a sponsor will wish to interject it into the process as his own system alternative. Unfortunately, an often-overlooked and certainly unappreciated risk factor is the cost required to integrate various COTS components from different vendors into a cohesive system that meets requirements. Especially misunderstood are unpredictable software costs required to achieve effective interfaces between hardware, software, and human operators, as well as to produce displays and features customized to the needs of the operational user.

Systems Analysis and Control

Systems analysis and control is an overarching activity that operates concurrently with the iterative processes spanned by requirements analysis, functional analysis and allocation, and synthesis (Figure 1). It covers a variety of analyses: tradeoff studies, effectiveness assessments, and system or subsystem design analyses and simulations to estimate progress in achievement of TPMs and overall requirements. It also employs several control mechanisms: risk management, configuration management, data management, and various technical reviews.

The analyses are conducted by the performing activity. The control activities are generally joint endeavors involving the tasking as well as the performing activity (MIL-STD-499B, 1994; EIA/IS-632, 1994). System analysis is considered more generally in a later section.

Systems Engineering Process Output

The systems engineering process should produce balanced, feasible system alternatives or solutions and a decision database that includes decision support data, system architectures, and specifications and design baselines from which the key decisions made during the process can be reconstructed and justified (MIL-STD-499B, 1994; EIA/IS-632, 1994). A framework and procedure for evaluation should also be established from which the final system design can be selected by the sponsor (Eisner, 1988).

What's Missing?

Is the systems engineering approach which we have just reviewed still viable in the current acquisition reform environment? Certainly it is central to the current acquisition process, which is universally regarded as needing reform and acceleration. Today, the acquisition program manager's challenge is to accelerate the development cycle, reduce costs, and maintain the capability to insert the most advanced technology appropriate for the stated need. Is the system engineering process part of the problem?

The key to meeting this challenge is found in the system analysis and control process, in which complex, highly visible, and continuing technical evaluations are conducted. These evaluations guide decisions regarding the design, capabilities, or selection of system alternatives. It is here that the systems architect may provide objective judgment and perspective to ensure a successful development process.

Technical evaluations may be grouped by function into four categories:

1. Evaluations that determine basic parameter values. For example, a technical evaluation may be necessary to determine the variation of an inertial navigation system's (INS) heading gyro drift bias as a function of platform azimuth. This evaluation may involve calculations, computer simulations, field tests, and measurements (Pace, 1986).

2. Evaluations that determine system performance. A system performance evaluation may determine the overall INS error growth as a function of time. The resulting tool might be a covariance simulation. Performance analyses are arguably the most visible type of technical evaluation, and can be the primary factor in discriminating between system alternatives (Atallah, 1993).

3. Evaluations that determine operational effectiveness by considering mission-level MOEs as a measure of the system performance. In our example, the ballistic missile system accuracy that is initialized by the INS depends on the accuracy of the INS, which may be dependent upon platform azimuth.

4. Evaluations that address concepts of operation, tactics, or strategy, and consider how the system will be used to satisfy mission objectives. Increasingly, weapon systems must be integrated into a larger, extant system of systems. The difficult analysis that predicts the marginal utility of the new system to the larger system of systems is often overlooked.

These technical evaluations use a variety of modeling and simulation methods. Figure 2 displays the full range of such

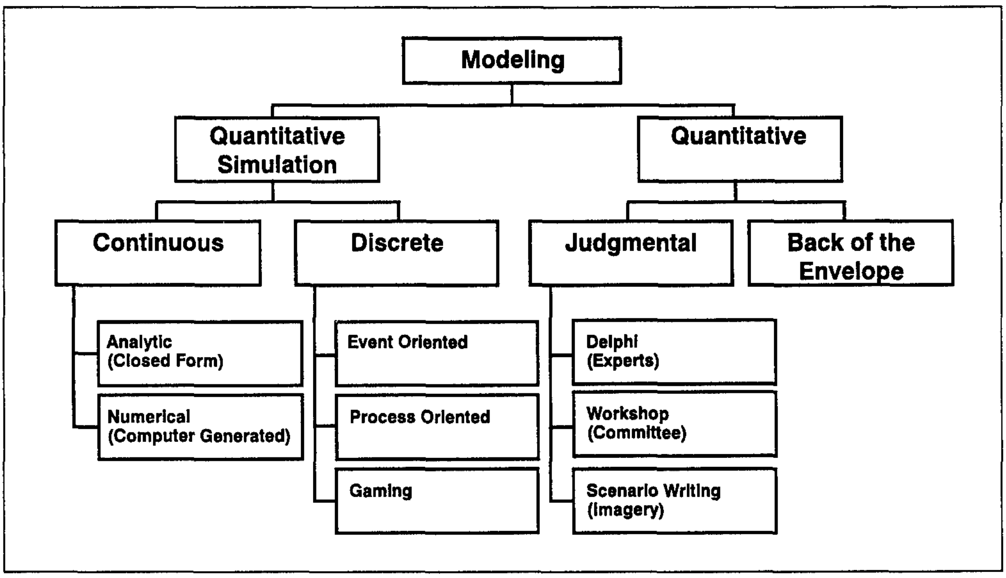

Figure 2. Modeling Taxonomy

techniques available to the systems analyst (Eisner, 1988; Scotti, 1994). However, it is the quantitative modeling methods that are the most commonly used in the systems engineering process. Laboratory experiments, field tests, and operational data from military exercises are important sources of validation data for the modeling and simulation processes.

Effective execution of the system analysis and control activity through judicious technical evaluations brings the following benefits to the systems engineering process:

- generation of system alternatives (including concepts of operation) that may more effectively or efficiently achieve the sponsor's objectives;
- explicit consideration of assumptions, uncertainties, costs, consequences, etc.;
- an objective framework and common basis for evaluating system alternatives and selection of a preferred alternative;
- improved understanding of the issues and hence better understanding on the part of the sponsor and ultimately the system users; and
- improved managerial capabilities for planning and administration of the system life cycle (Miser and Quade, 1985, pp. 25–26).

There are, however, adverse consequences that can arise from dependence on systems analysis beyond the level appropriate to the scale of the problem:

- unwanted delays in system development;
- undesirable centralization and concentration of decision making in top-level staff;
- increased dependence on complex processes (e.g., simulation) that require expensive talent to operate; and
- loss of risk mitigation capability through elimination of apparent inefficiency and redundancy.

A system developer may seek to avoid detailed technical evaluations, citing the potential for schedule impact as a justification. This position may also be motivated by a lack of qualified people to do the evaluations, or concern that an analysis will encourage reconsideration of an alternative already effectively discarded. However, a vibrant, objective, ongoing systems analysis is essential to the maintenance of systems perspective, especially in regard to the "system of systems." The standard systems engineering process does not address this overall architecture question, generally considering the system under development as an isolated entity.

Systems Architecting

A broad role growing out of systems analysis and control in the systems engineering process has recently been characterized as *system architecting* (Rechtin, 1991, 1994). The function of a system architect is to act as the system development agent of the program manager, to create and manage the design, to maintain system integrity, and to help achieve user satisfaction with the procured system. Hence it is a role that exists at the level of the acquisition process, yet may also contribute to the engineering of a system.

The discussion of systems analysis presented above has focused on tradeoff studies, quantitative technical evaluations, system integration, and interface management—all within the context of the systems engineering process. However, the role of the system architect goes beyond systems engineering to include the comprehensive synthesis, certification, and qualitative satisfaction of user needs—all of which are goals of the Integrating IPT (USD[AT] and ASD[C^3I], 1995. System architecting applies systems analysis methodology to the acquisition process, rather than operating strictly within the confines of the single systems engineering process, per se.

Another way to understand system architecting is to contrast its tasks with those generally performed as part of systems engineering. Architecting is working *for* the program manager and *with* a system developer; engineering is working *with* an architect and *for* a system developer. In short, the core of architecting is system integration and a continuing verification that the desired product is being obtained. Figure 3 illustrates the scope and potential value added by the architect throughout the life cycle of the system.

The military has long recognized the need for system architects in the acquisition process, though that terminology is not widely used outside of the software engineering specialty. The term technical direction agent (TDA) reflects a role similar to what we have discussed for the system architect:

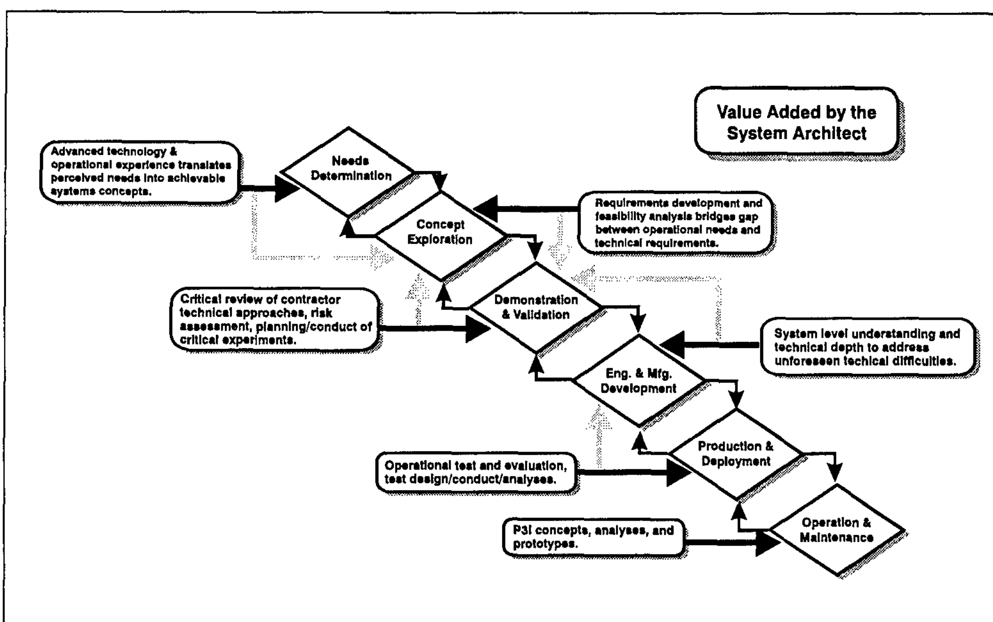

Figure 3. System Development Process

> The TDA assists the level III System Manager in the establishment of initial program concepts, performs system engineering, develops performance specifications, and performs or directs research, development, test and simulations to investigate problems, probe alternative approaches, and to evaluate design agent achievements. (Department of the Navy, 1985)

To summarize the role of the system architect, it will help to define some terms:

- The "system" is what is built.
- The "model" is a description of the system to be built.
- The "system architecture" is the structure of the system.
- The "overall architecture" includes the structure not only of the system, but of its functions, the environment within which it will operate, and the process by which it will be developed and operated (Rechtin, 1991, p. 75).

The systems architect is then concerned with the overall architecture, not just the system architecture, the model, or associated technical evaluations.

The System Architect in the Integrated Product Team

Increasingly in this era of joint and combined operations, systems must interoperate with other systems, forming a "system of systems" that offers a true warfighting capability. Hence many acquisition programs are justified and judged on their marginal utility to the effectiveness of this larger "system of systems." This is the perspective of the system architect. Furthermore, the Integrated Product Team is an excellent, cooperative vehicle that can easily accommodate establishment of the system architect as the integrating IPT chairperson, acting as the design agent of the program manager. Depending on the particular program and the technical knowledge required, the system architect role may be satisfied by one of the following.

1. The program manager or his or her staff.
2. A government laboratory.
3. A university laboratory.
4. A nondevelopment division of a systems contractor.

Recalling our earlier discussion about industry investments and COTS technology, it is critical that DoD sponsors have the best possible perspective and knowledge available when buying in the technological marketplace. This must be provided with a competence, integrity, and objectivity beyond question. It is not reasonable to go to the free enterprise marketplace from which the government will buy its systems and ask for advice on which systems to buy. Conversely, the system architecting organization has no potential for conflict of interest, as it is not a candidate to develop the operational system, though it may well build prototypes as part of the technical evaluation processes described above. This independence from the business of operational system development and production means that the system architect doesn't come to analysis or architecting with a particular technology or system solution in mind. Indeed, the architect is obligated to table the sponsor's initial agenda or solution (typically, the sponsor has one in mind, stated or not) until the problem is sufficiently understood and structured.

The in-house institutions that perform this role are sometimes referred to as "research and development centers" and take the form of either military or university laboratories. These laboratories, and the government, realize that they must have full knowledge of military operations and the implications of technology, which cannot be gained by mere observation. In short, they train to be system architects, or independent systems analysts operating at the acquisition level, whose role spans the full spectrum from research and development through operational performance evaluation in the field or at sea.

Perhaps the strongest argument for this independent architecting in the DoD acquisition process is that it can reduce cost and improve the product in spite of government contracting procedures. To illustrate: The government frequently punishes a contractor more severely for underrunning than it does for overrunning (Kershner, 1981). This is an almost inevitable consequence of the DoD contracting practice for systems being developed as opposed to those in production. In the former case, the contract is typically of the "cost plus" variety because the costs of development are too uncertain for either the contractor or the government to agree on a fixed price. Nevertheless, the cost and schedule estimates generated at the start of a program will form the basis for significant allocations of resources and staff to which the contractor and the government are then committed. Consider, however, how this may affect an ongoing program in which an innovative application of advanced technology might halve the remaining cost and schedule of development. This innovation may create a conflict of interest for the contractor, who was counting on the initially agreed-on funding and schedule to gainfully employ significant numbers of staff. In this case an independent system architect could be relied on to uncover the new technology application and present it to the system developer and sponsor.

Situations of this magnitude are rare, but a independent system architect, working within the constructive atmosphere of the Integrating IPT, can make significant, consistent contributions toward integration.

SUMMARY

Systems analysis applied to the acquisition process, sometimes described as system architecting, is vital to successful development of complex systems and systems of systems. The architect role is best performed by an agent of the government program manager (and, thus, independent of the system developer) who can be relied on to ensure sponsor satisfaction with the final system. The accelerating pace of technology, the aggressive investment in and marketing of components and systems by the private sector, and the increasing complexity of military needs all mandate an ever more sophisticated government consumer. The system architect must offer a broad expertise in the state-of-the-art technology, information systems, and a knowledge of mission operational needs, as well as the skill to apply this knowledge in a cost-effective manner.

The acquisition program manager can maintain this vision and focus by appointing a system architect, independent from the system developer or contractor, to chair an essential Integrated Product Team. This is especially critical in the context of a "system of systems" development environment, wherein program success will ultimately be judged on the marginal utility of the new or upgraded system to the entire system of systems' effectiveness.

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DAWIA AND THE PRICE OF PROFESSIONALISM

Keith F. Snider

This article examines the intent and outcomes of the Defense Acquisition Workforce Improvement Act (DAWIA) in light of research literature on the sociology of the professions. It indicates that professionalization is leading to an acquisition workforce that is expert and specialized, yet insular and careerist. Professionalism thus comes at a price, and a major question for those dealing with acquisition workforce reform issues is how to keep this price as low as possible.

Five years after passage of the Defense Acquisition Workforce Improvement Act (DAWIA), it is appropriate to examine the act—its intent, provisions, and outcomes—in some perspective. Scholars (e.g., Fox, 1974, 1988), presidential commissions (e.g., President's Blue Ribbon Commission on Defense Management, 1986), and Congressional committees (e.g., U.S. Congress, House, 1990b) alike have devoted considerable study to the topic of workforce reform. Yet the need for additional study remains as new legislation is aimed at the acquisition workforce (U.S. Congress, Senate, 1995), and as current trends toward "downsizing," "rightsizing," reengineering, and reinventing continue into the future.

The subject of this paper may be introduced with an anecdote from the author's experience in teaching portions of Defense Acquisition University (DAU) courses. At the beginning of one recent course, students introduced themselves and explained their reasons for attending. One might have expected that these relatively senior civil servants and military officers would cite reasons relating to professional education and personal development. Without fail, however, most students gave a reason that smacks of the self-serving careerism known as "ticket punching:" to obtain the certification for training required as a result of DAWIA.

This apparently careerist frame of mind in our acquisition workforce should not surprise us. A significant body of research concerning the sociology of the professions indicates that this is an entirely predictable, albeit unintended, consequence of DAWIA. Some of this research explores the prestige and competency aspects of professions and may be useful in understanding the intent of DAWIA. Another more critical area of the research focuses on what happens to occupations as they become professionalized; that is, as they gain professional status. Professionalization is generally seen as a positive movement in the direction of improving the quality and status of an occupation, but research also reveals unintended consequences of professionalization that oppose the outcomes intended by those seeking such status. Probably the most obvious example of the unintended consequences of professionalization is provided by the legal profession, once highly respected in American society, but now often criticized for being insular and self-serving.

Professionalism thus comes at a price. This paper will review the research literature to expose and explore that price: the "dark side," so to speak, of acquisition workforce professionalization. It will reveal the essentially problematical nature of professionalization, thereby questioning DAWIA's assumptions about workforce improvement leading to reform of the overall acquisition environment.

Attribute Models: Capturing the Intent of DAWIA

Occupations and professions became important subjects of sociological research during the first part of this century as scientific and technological advances led to an ever-increasing level of diversification and specialization in the workforce. Emerging occupations sought the same level of prestige accorded the four traditionally recognized professions: law, medicine, the ministry, and university teaching (Etzioni, 1969). The aspect of prestige is evident in this classical definition of the word *profession*:

> *Profession:* a calling requiring specialized skills and methods as well as in the scientific, historical, or scholarly principles underlying such skills and methods, maintaining by force of organization or concerted opinion high standards of achievement and conduct, and committing its members to continued study and to a kind of work which has for its prime purpose the rendering of a public service. (Webster's Third New International Dictionary, 1961)

From this classical perspective, certain qualities are attributed to professions (Pavalko, 1988):

(1) A unique knowledge base justifying the claim to special expertise.

(2) A long training period requiring specialized knowledge and indoctrination into the occupational subculture.

(3) Relevance of work to social values.

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(4) A service versus a profit motivation.

(5) Occupational autonomy. The profession is self-regulating and self-controlling. Only members of the profession judge and certify who is competent to practice.

(6) A strong sense of commitment and loyalty to the profession.

(7) A strong sense of a common identity resulting in a significant subculture.

(8) A code of ethics and system of norms that are parts of the subculture, reinforcing motivation, autonomy, and commitment.

Because of these attributes, professions are perceived to exhibit that high quality of work in terms of requisite expertise, experience, and dedication to service which justifies public trust and respect. Early research in the sociology of the professions documented these attributes and the associated quest among emerging occupations to gain the status of professions by taking on their attributes. For example, caseworkers led the move during the 1920s to establish formal training programs leading to certification in the budding field of social work (Larson, 1977).

The attribute models of the professions are useful in understanding the putative intent of DAWIA, as reflected in the title of a National Contract Management Journal article, "Creating a Professional Acquisition Workforce," by former Congressman Nicholas Mavroules (1991), one of the architects of DAWIA. Nothing in his article, in the text of the legislation, or in the record of relevant Congressional hearings (U.S. Congress, House, 1990a) indicates an explicit intent to establish the field of acquisition as a profession per se. Nevertheless, the goals of making the acquisition workforce professional and of increasing the professionalism of the workforce are clear.

One need not belong to a profession in order to be professional or to exhibit professionalism. Yet these words refer to and take the power of their meaning from the high classical concept of profession as reflected in the attribute model. To be professional or to have professionalism means therefore to act as though one belonged to an occupation with at least some of the attributes of the traditional professions.

The intent of DAWIA is to make members of the acquisition workforce professional by treating them as though acquisition has some of the attributes of a profession. Specifically, acquisition is seen as possessing the attributes of a unique knowledge base requiring extended training and experience. The workforce then becomes professional by meeting the requirements for acquisition education, training, experience, and tenure provided for under DAWIA.

A brief discussion of how this relates to some military members of the acquisition workforce will illustrate this point further. Some sociologists (e.g., Jackson, 1970) include the military as one of the traditional professions. Indeed, the "profession of arms" fits the attribute model well. It's also true that the warrior's unique knowledge and skills in the art and science of war are valued in the field of acquisition, particularly in understanding the operational use of equipment under development (U.S. Congress, House, 1990a, p. 184). But, as Kronenberg (1990, p. 286) points out, the warrior orientation does not easily accommodate itself to the complexities of management in the Department of Defense (DoD). Professional warriors are often seen as amateurs in acquisition:

> ... the Army, the Navy, and, to a lesser extent, the Air Force provide only limited industrial management training for military officers whom they assign to key managerial positions in major acquisition programs. Army and Navy officers assigned to acquisition programs often have extensive combat arms experience (e.g., as pilots, ship captains, armor commanders) but little or no advanced training and experience in the planning and control of industrial development and production programs. (Fox, 1988, pp. 40–41)

The implicit views expressed here are: first, that acquisition has the attributes of a unique knowledge base requiring extensive training and experience; and second, that the skills and training of the professional warrior—the pilot, the ship captain, and the armor commander—are inadequate for tasks in acquisition.

Further supporting this view that military members are not professionals in acquisition has been the practice of the military services to rotate officers frequently in and out of key positions (Kronenberg, 1990, p. 286). This environment in which military amateurs hold key acquisition positions is, according to Mavroules (1991, p. 15), one of the root causes of the nation's continuing acquisition problems.

DAWIA aims to correct this situation. It recasts warriors as acquisition professionals by requiring them to undergo education and training in acquisition, to devote perhaps most of their careers to jobs in acquisition, and to forego more frequent career-broadening rotations in favor of longer tenure and stability in key acquisition positions. These requirements will inevitably force young officers to choose early in their careers whether to proceed as warriors or as acquisition professionals, because the training and experience necessary to do both successfully is simply too extensive. DAWIA encourages such an early decision toward a career in acquisition by requiring that paths be identified for officers to progress from entry level all the way to the most senior acquisition positions.

Similarly, the acquisition workforce as a whole, through compliance with education, training, experience, and tenure requirements, is made professional and improved, reflecting the quality associated with the classical view of the professions. The intent of DAWIA is thus consistent with the Total Quality Management (TQM) view that investments in employees are investments in agency capacity (Lane and Wolf, 1990, pp. 83–84; White and Wolf, 1995, p. 213). The expectation is that the return on these investments in the workforce will be improvements in the processes of acquisition. According to Mavroules (1991, p. 16), "more qualified people should make for a more efficient acquisition system that will give us more bang for the buck."

Of course, not everyone agrees that such an investment is appropriate. Some believe that the nature of defense acquisition is such that no professional skills are required. Former Office of Personnel Management associate director Terry Culler (1986, p. 32) argues that a civil servant with any more than an acceptable level of competence is overskilled and overqualified for government service. The government cannot afford to hire the best and the brightest. The proper place for these professionals is in the private sector "where they can contribute to the process of wealth creation necessary to maintain a healthy society." Others argue that the present acquisition system and processes are so seriously flawed that no amount of professionalism in the workforce can bring about improvement (Library of Congress, 1985, p. 5). From this perspective, radical reform of the overall system is more urgently needed than workforce reform.

Apart from these critiques, there remains the question of whether we can, at some future time, ever know whether or not DAWIA has produced its desired consequence of an improved acquisition system. If, for example, we experience fewer programs with cost overruns, can we say with any certainty that the professionalism of the workforce was a causal factor? Suppose on the other hand that we experience greater numbers of programs with overruns. Can we say that DAWIA led to this state of affairs? Or would the situation have been even worse without the legislation?

The uncertainties and ambiguities surrounding the analysis and evaluation of complex policies are well documented (e.g., Nakamura and Smallwood, 1980). Clearly, we have no models or techniques that can either portray all relevant acquisition variables or predict the effects of different acquisition policies without bias. We are therefore left with fundamental uncertainties about whether or not DAWIA will have its intended consequences.

Unintended consequences, however, are another matter entirely. We have substantial research evidence, again from the sociology of the professions, that points to some troubling potential outcomes of DAWIA. Since it is not evident that these were considered in the debate leading to passage of DAWIA (or for that matter in any prior attempts to reform the acquisition workforce), their explicit consideration is, at this time, appropriate.

Process Models: Revealing The Dark Side of Professionalization

Process models of the professions arose as a response to critiques of attribute models. Some sociologists argued that the assumptions of attribute models, particularly the assumption that clients are better served as workgroups become more professional, lead to an emphasis on the positive side of professions, thereby overlooking implications of power. From this perspective, the power of a professional group, derived from its claims of expertise and special status, is used primarily to benefit the group's membership in ways frequently at odds with the public interest (Friedson, 1986).

These models describe the steps in the process of *professionalization*, defined as "giving a professional character to, treating as, or converting into a profession" (*Webster's Third New International Dictionary*, 1961). The specific steps in the process and the order in which they occur vary from researcher to researcher, but in general follow the same basic pattern (Wilensky, 1964):

(1) A "critical mass" of workers is involved in the work activity.

(2) The work becomes a full-time activity.

(3) Training schools are established to transmit the skills of the work.

(4) University programs are established.

(5) Professional associations are formed.

(6) Competition occurs with neighboring occupations over the boundaries of the work.

(7) A code of ethics is developed.

(8) Political action (e.g., lobbying) is taken for legal protection and restrictions.

The path of this process is one of increasing specialization and differentiation of the occupation. The occupation gains status by portraying itself as possessing unique knowledge and skills; indeed, the more unique the skills, the stronger the claim to professional status (Foote, 1953). Occupations are motivated to emphasize their uniqueness and are under tacit pressure to develop their own separate bodies of knowledge (Larson, 1977, p. 201). Levels of understanding, perspective, and communication across occupational boundaries decrease as the level of isolation increases (Mosher, 1968, pp. 122–123). The focus of the occupation turns increasingly inward toward its own survival and maintenance at the expense of service to the public. Claims to separateness are legitimated and a facade of public service is maintained through symbols such as university programs, certification procedures, and codes of ethics.

The work group becomes more concerned with taking on and maintaining the outward manifestations of professionalism than with its substance. In particular, completion of required training programs and other certification requirements become ends in themselves rather than means to improved quality of service, and the accompanying certificate becomes proof of professionalism. Thus, the salesman of burial plots is no longer a salesman, but a "professional memorial consultant" with a diploma issued after a one-week training course to prove it (Liberman, 1970, p. 52).

Process models lead to a critical interpretation of what attribute models mean. The creation of a specialized knowledge base, claims of service motivation, commitment, codes of ethics, and other attributes are revealed as no more than myths created by work groups in competition for the rewards and privileges to be gained by the recognition as "professional" (Pavalko, 1988).

Liberman's (1970) analysis is especially critical. Pointing to the medical and legal professions, he argues that, since professionalism springs from the exercise of specialist skills, judgments relating to competence or proper professional conduct may be exercised only by the professionals themselves; that is, only professionals are qualified to judge themselves. Decisions regarding the profession may be rightly made only by the professionals, and the maintenance of the profession is their principal function. Lawyers, for example, *are* the legal system. Professionals exercise a tight self-serving control over their fields, hence the title of Liberman's book, "Tyranny of the Experts."

It must be noted that this literature provides no evidence that these troubling outcomes stem from any conscious malevolent intentions of work group members. Rather, the movement toward specialization and insularity occurs in a subconscious or unconscious way that is consistent with Niebuhr's (1960) description of the way injustice tends to arise in any large organization. During professionalization, members continue to believe that they are "doing the right thing;" that is, elevating the quality of both their work and themselves in the best interests of the public. Actions such as political lobbying for legislation favorable to the profession, for example, would be justified by its members as in the public interest.

DAWIA AND PROFESSIONALIZATION: CURRENT TRENDS

How does this research relate to DAWIA? It's clear that defense acquisition is proceeding along the path of professionalization as described by the process models. (We may debate the precise point in the process at which acquisition stands [some might argue that some acquisition career fields, contracting for example, have completed all the steps.] But to what purpose?) These models tell us that DAWIA is a point on that path, and well-intentioned as it may be, the legislation will have consequences: a price of professionalism. We may begin to gauge this price by looking at the implementation of some of DAWIA's provisions, which indicates a trend of continuing specialization and insularity of the acquisition workforce, with a concomitant focus on the trappings of professionalism.

Most obvious of course is DAWIA's institution of an Acquisition Corps for the various components of DoD. DAWIA's provisions for selection criteria for corps members and for the designation of critical acquisition positions that may be filled only by members meeting special education, training, and experience requirements, mean that this Corps will be a highly specialized group, separate and differentiated from others within DoD.

Second, DAWIA's provision for a university (DAU) to conduct educational development, training, and research and analysis for acquisition means that these functions will be executed in an increasingly separate environment. While the Defense Systems Management College (DSMC) has historically been the leading institution in acquisition training and research for DoD, each of the services has to some degree maintained its own acquisition training capabilities (e.g., the Army Logistics Management College). Under DAWIA, the centralization of acquisition training management means that these institutions now to a significant degree operate under and respond to DAU and are thereby distanced from their respective services.

Third, within the Acquisition Corps, separate and distinct career fields (e.g., program management, acquisition logistics) are institutionalized by DAWIA. Each career field has been determined to have its own set of competencies: a unique body of knowledge. This means that there will be movement toward specialization and differentiation *within* the acquisition workforce. For example, each career field will have its own training and certification requirements and its own professional society (e.g., National Contract Management Association, Society of Logistics Engineers). Each career field will become increasingly expert and specialized, but also increasingly differentiated and isolated from other career fields. (The specialization of the program management career field, which is associating with the civilian-oriented Project Management Institute [U.S. Department of Defense, 1994, pp. 2–3], is ironic, given the DoD program manager's traditional role and responsibility of integrating the efforts of the various acquisition functional areas.)

The separation of the career fields will be exacerbated by the current arrangement in which most DAU consortium schools offer courses in only a few career fields. Budgetary pressures, "turf" issues, and steady-state enrollments will keep schools from expanding their offerings into other career fields. The tendency will be for schools to "play to their strengths" when faced with these pressures, which may lead to a consortium of DAU specialist schools, each specializing in only one or two career fields.

As discussed earlier, the institution of certification requirements leads to a view of certification as an end rather than a means. The same budgetary pressures will force DAU student enrollments and the duration of required training to minimal levels. Acquisition workforce members will be pressured to get training certification (to "punch their tickets") in their career fields, with little regard for the content or substance of the training.

Other points may be noted, but the trend is evident. While the acquisition workforce may indeed be growing more professional, the price of this professionalism is its growing insularity from the rest of DoD. As the process continues, levels of understanding and communication between the acquisition workforce and other DoD professionals (the warriors, the personnel specialists, and others) will decrease. More troubling, the perspective of each acquisition career field will narrow as it becomes: first, increasingly preoccupied with its own discipline; second, more firmly convinced that it has all the right answers; and third, less able or willing to see and hear what is going on in other career fields. The acquisition logisticians, for example, may be superb professional logisticians who are completely incapable of communicating outside their discipline. Granted, such a workforce may be more professional according to our definitions, but is it really *improved?*

This illustrates the essentially problematic nature of professionalization. As we respond with increasing specialization to what we see as the increasingly technical challenges of acquisition management, we create new problems for ourselves. And still we do not know if we are curing the nation's acquisition ills.

KEEPING THE PRICE LOW

Given that there is a price to be paid for professionalism, our objective should be to keep that price as low as possible. What can we do to keep the acquisition workforce from becoming too insular and to maintain a balance between specialization and perspective across disciplines and career fields? We may begin by looking for examples of professional education and training that aim to broaden perspectives among members of the profession. Such examples can impart insights and stimulate debate on the best way to proceed from where we are now.

One possible exemplar is the professional education and training of Army officers. (Navy, Marine Corps, and Air Force officers have similar professional education and training programs.) In this model, specialized professional training occurs early, essentially at the entry level. Generalized training takes over very soon thereafter and continues throughout the remainder of the officer's career. Specifically, between commissioning and about the fifth year of service, the officer receives several months of specialized training in the skills and equipment peculiar to his or her basic branch at an Army school that specializes in that branch (e.g., infantry training occurs at the Infantry School and Center at Fort Benning; signal training at the Signal School and Center at Fort Gordon). After this point, institutional education and training is almost exclusively generalist. It focuses on combat command and staff operations, leadership, and management not only across the Army's basic branches, but across service and national boundaries as well. Officers of all branches receive this integrative and interdisciplinary training together at institutions chartered to conduct this type of generalist training (e.g., the Command and General Staff College [CGSC] at Fort Leavenworth).

The sheer volume of this type of training is also instructive. Top officers spend about a year in mid-career resident training at CGSC and later spend another year in residence at a Senior Service College.

Does this model of training preclude the presence of ticket punching careerists, the "price of professionalism," among Army officers? No, it simply keeps this price low.

We may envision such a model applied to the acquisition workforce. Entry-level members might receive specialized career field training at specialist acquisition schools around the country. Mid-level and senior members from all career fields, on the other hand, would meet together in residence at one or two selected acquisition research and teaching institutions, and devote extensive study to a broad range of issues cutting across the various career fields. (Such long-term residential programs have been suggested in the past [U.S. Congress, House, 1990ab, p. 219; Stupak, 1993, p. 22], and the Senior Acquisition Course at the Industrial College of the Armed Forces appears to be a move in this direction.) The current practice of awarding intermediate and senior level training certification on the basis of completion of one- or two-week courses would be abandoned in favor of long-term resident study programs.

Clearly, there would be many challenges to be met and substantial investments to be made to make such programs a reality.

Conclusion: Two Visions of the Future Workforce

In conclusion, I offer two possible visions of the state of the acquisition workforce in 25 years. One vision is of disconnected groups of specialists, each narrowly focused on their own particular piece of the acquisition puzzle. The other vision is of a workforce that takes the broad view, bringing together diverse skills and perspectives to determine how best to fit together all the pieces of the puzzle. The dialogue on which vision we choose to make reality should begin now.

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DOD'S 5000 DOCUMENTS: EVOLUTION AND CHANGE IN DEFENSE ACQUISITION POLICY

Joe Ferrara

The article begins with a brief discussion of the origins of the 5000 documents. Then the author analyzes the nine different versions issued between 1971 and 1993, highlighting the major principles and themes of each issuance, the principal catalyst behind each revision, and the significant changes evident from one version to the next. The article concludes by reviewing likely changes to be pursued in the near future as various acquisition reform study efforts near completion and DoD revises 5000 once again.[1]

By any measure the defense acquisition system is undeniably complex. Hundreds of thousands of employees work in DoD acquisition organizations, which execute millions of contract actions every year. Until very recently, the total DoD acquisition budget exceeded $100 billion annually. Major defense acquisition programs, which account for a large share of this total budget authority, are technologically advanced products, often designed to achieve performance levels never before realized. The resulting high levels of uncertainty and technical risk demand skilled and intelligent management.

Since the early 1970s DoD executives have used a few key policy documents to govern the sprawling defense procurement empire. DoD Directive 5000.1 and its accompanying DoD Instruction 5000.2 (hereafter DoDD 5000.1 and DoDI 5000.2) have been the foundation of the defense acquisition process for over 20 years. Since 1971 DoD has issued a new version of DoDD 5000.1 and DoDI 5000.2 nine different times. During this period, DoD has developed and produced hundreds of major acquisition programs under the broad principles articulated in these documents. Literally thousands of career employees and political appointees have played a role in these various revisions.

Based on their longevity and relatively frequent revisions, the 5000 documents offer a unique window on the evolution of policy in a major government department. Reviewing this policy evolution is especially relevant today as the Clinton administration continues its ambitious program of acquisition reform. Many of the emerging reform recommendations—from military specifications and standards to pilot programs—involve some sort of proposed change to DoDD 5000.1 and DoDI 5000.2. A good example is the recently completed Oversight and Review process action team, whose final report deals directly with many of the processes and procedures set forth in the 5000 documents (Process Action Team, 1994).

Given the inextricable connection between the 5000 documents and the way that DoD manages its acquisition process, and the current emphasis on acquisition reform, it would be useful to gain some historical perspective on the development and evolution of the 5000 documents. What were their original purpose? Why and how have they been changed over the years? How do these changes illustrate larger trends in defense acquisition management? What are the prospects for future policy development? These questions are the main focus of this paper.

After a brief discussion of the origins of the 5000 documents, this article analyzes the nine different versions issued between 1971 and 1993, highlighting the major principles and themes of each issuance, the principal catalyst behind each revision, and the significant changes evident from one version to the next. It concludes with a review of likely changes to be pursued in the near future as various acquisition reform study efforts near completion and DoD revises 5000 once again.

THE ORIGINS OF POLICY

How did the 5000 documents become the principal vehicle for managing defense acquisition? To answer that question it is necessary to turn our attention back to President Richard Nixon's first term, when Melvin Laird was Secretary of Defense and a politically active industrialist named David Packard was serving as Laird's Deputy. Energy and environmental programs were gaining widespread currency while the increasingly unpopular war in Vietnam and the rising costs of defense acquisition began to result in congressional disenchantment with DoD weapons programs. (Acker, 1982)

This disenchantment led in turn to determined congressional attempts to reduce defense spending. As the Vietnam drawdown began and defense spending declined, Laird and Packard recognized that they needed a mechanism for effectively managing defense acquisition and controlling cost growth, especially in an environment of fiscal constraint.

Establishing a formal acquisition management regime was the solution they

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settled on. In May 1969 Packard formed the Defense Systems Acquisition Review Council (DSARC) to serve as an advisory body to the Secretary of Defense on matters concerning acquisition of major weapon systems (Packard, 1969). The original DSARC was chaired by the Director of Defense Research and Engineering (DDR&E) and was chartered to review major acquisition programs at major milestones in the acquisition cycle. In addition, Packard directed DDR&E to conduct occasional management reviews of major programs.

In May 1970 Packard issued another policy memorandum on defense acquisition (Packard, 1970). This memo articulated many of the broad themes that would later become the foundation for the 5000 series, including decentralized execution, streamlined management structures, and use of appropriate contract mechanisms. According to Packard, the primary objective of DoD oversight was to "enable the Services to improve the management of their programs." Packard clearly believed that the defense acquisition system needed improving: "It is imperative that they [the Services] do the job better than it has been done in the past." The May 1970 policy memo established broad guidance in five major areas: management, conceptual development, full scale development, production, and contracts. Approximately a year later, in July 1971, the first DoDD 5000.1 was formally issued.

The Founding Document: DoD Directive 5000.1, July 1971[2]

Measured against the standards of today's DoD directives and instructions, the first DoD Directive 5000.1 was in many ways a very austere document: Only seven pages long, it described the acquisition-related duties of only three DoD officials[3] and included references to only a handful of other policy documents. In many ways, the entire acquisition reform agenda since 5000.1's original publication in 1971 can be characterized as one long effort to realize the simple but powerful vision contained in Packard's founding document:

> Successful development, production, and deployment of major defense systems are primarily dependent upon competent people, rational priorities, and clearly defined responsibilities. Responsibility and authority for the acquisition of major defense systems shall be decentralized to the maximum practicable extent consistent with the urgency and importance of each program.
>
> The development and production of a major defense system shall be managed by a single individual (program manager) who shall have a charter which provides sufficient authority to accomplish recognized program objectives. Layers of authority between the program manager and his Component Head shall be minimum... [the] assignment and tenure of program managers shall be a matter of concern to DoD Component Heads and shall reflect career incentives designed to attract, retain, and reward competent personnel.

It is not too difficult to trace the intellectual heritage of many of today's statutes, policies, and institutions such as the

Defense Acquisition Workforce Improvement Act, the streamlined acquisition chain of command, and the Defense Acquisition University, to these five sentences.

The first DoDD 5000.1 applied to all acquisition programs, although it referred specifically to "major programs," to be designated by the Secretary of Defense on the basis of "dollar value,[4] national urgency, or recommendations by DoD Component Heads or Office of the Secretary of Defense (OSD) officials." While OSD and the Components were charged with program monitoring, the directive was careful to "place minimum demands for formal reporting on the program manager."[5]

The directive described three significant decision points: program initiation, full-scale development, and production/ deployment. Each one of these decision points required the approval of the Secretary of Defense. Program initiation occurred at some point in time after "early conceptual efforts" when the Component Heads in question determined "that a major defense system program should be pursued." Entry into full-scale development would occur when the Component "is sufficiently confident that program worth and readiness warrant commitment of resources to full-scale development." Similarly, entry into production would be approved by the Secretary when the Component could demonstrate that "engineering is complete."

The final section of the 1971 DoDD 5000.1 was entitled "Program Considerations." This section described a number of important requirements pertaining to progression of a program through the acquisition process, including: (1) wherever feasible, operational needs shall be satisfied through the use of existing military or commercial hardware, (2) practical tradeoffs shall be made between system capability, cost, and schedule, (3) logistic support shall be considered as a principal design parameter, (4) schedules shall be structured to avoid unnecessary overlapping or concurrency, (5) test and evaluation shall commence as early as possible, (6) contract type shall be consistent with all program characteristics, including risk, (7) source selection decisions shall take into account the contractor's capability to develop a necessary defense system on a timely and cost-effective basis, and (8) documentation shall be generated in the minimum amount to satisfy necessary and specific management needs.

The first DoDD 5000.1 included one enclosure entitled "Related Policy." This enclosure delegated responsibility for preparation of related policy documents to a few OSD officials. Development of a policy document on the defense technology base, for example, was delegated to the DDR&E. Preparation of a document on cost analysis was delegated to the Assistant Secretary for Systems Analysis (now the Director of Program Analysis and Evaluation). Establishment of a policy document on logistic support was assigned to the ASD for Installations and Logistics (now the Deputy Under Secretary of Defense for Logistics). In all, the enclosure described 14 separate policy subjects to be documented in official policy memoranda.

THE DOD 5000 SERIES:1971–1995

An analysis of subsequent issuances of the 5000 series. In the discussion below, particular attention is paid to major principles and themes, policy complexity, and policy context. The questions addressed include:

- What have been the major principles and themes articulated in the 5000 series? In other words, what have been the "constants" of defense acquisition policy?
- What have been the major changes and shifts in acquisition policy? What has been the political-historical context surrounding the major revisions?
- What conclusions can be drawn from this policy history?

At the end of the paper is a table that summarizes the key differences, and similarities, among the various 5000 editions.[6]

THE 5000 SERIES: POLICY STABILITY

The constant pressure to reform and improve DoD's acquisition processes notwithstanding, it is interesting to note that with very few exceptions there has not been wide variation in the fundamental management principles underlying the defense acquisition system. The founding 5000.1 set the tone and all subsequent documents have been remarkably consistent in continuing to articulate a few key themes. This is remarkable because, as even the most casual observer of the DoD procurement scene is aware, the last two decades have witnessed an extraordinary and persistent agitation for reform and improvement. The juxtaposition of "timeless" management principles etched in the granite of the 5000.1 and the nonstop calls for reform raise a very interesting issue: While DoD seems to have become quite accomplished at preaching the values of good management, the Department appears quite dissatisfied with its efforts to practice what it preaches.

What are the constant principles and themes? A review of all the 5000 issuances since 1971 reveals that a few in particular stand out in each version of the directive:

Centralized Policy, Decentralized Execution. Each 5000 series revision since 1971 has stressed the importance of centralized policy-making and decentralized program execution. The two examples below illustrate the kind of language used to communicate this principle. The 1971 revision states:

> Responsibility and authority for the acquisition of major defense systems shall be decentralized to the maximum extent practicable consistent with the urgency and importance of each program.

The 1977 version states:

> Responsibility for the management of system acquisition programs shall be decentralized to the DoD Components except for decisions retained by the Secretary of Defense.

The logic underpinning this principle is simple but persuasive: Policy formulation and adoption are best done by central actors because they have a broader appreciation of the entire Department's interests than do local actors, such as program managers or contracting officers. On the other hand, local actors are best positioned to manage the day-to-day affairs of defense programs and projects: making cost-performance tradeoffs, negotiating with suppliers, and managing contract performance. Each 5000.1 issuance from 1971 to 1986 used some close variant of the 1977 language above. Later versions have expanded this concept in new sections on subjects such as "tailoring" and "streamlined acquisition organizations."

Fly Before Buy. Another consistent theme has been "fly before buy," which generally refers to activities, such as prototyping and operational test and evaluation, designed to enhance understanding of technical challenges and mitigate associated risks before a commitment to production is made. Consider the two examples below, the first from the original 1971 document, the other from the 1987 version:

> Technical uncertainty shall be continually assessed. Models, mock-ups, and system hardware will be used to the greatest possible extent to increase confidence levels.... Test and evaluation shall commence as early as possible. A determination of operational suitability, including logistic support requirements, will be made prior to large-scale production commitments, making use of the most realistic test environment possible and the best representation of the future operational system available. (1971)

> Competitive prototyping of critical components, subsystems, or systems and early operational test and evaluation beginning in the concept demonstration and validation phase are encouraged and shall be emphasized. (1987)

Streamlined Organizations. Each 5000 reissuance has also emphasized the need to keep the number of management layers to a minimum. The 1987 version, for example, stated that DoD Components "shall establish a streamlined management structure" for managing acquisition programs, and that "program management direction shall only be issued by and flow through this streamlined management structure." Similarly, the 1991 issuance called for "short, clear lines of authority and accountability." "No more than two levels of review shall exist between Program Managers and their designated milestone decision authority." The 1991 version also made a point of singling out "boards, councils, committees, and staffs" as existing only to provide "advice to those responsible for managing programs." Such entities, however, will have "no authority to and shall not issue programmatic direction or impede the orderly progression of programs through the acquisition process."

Limited Reporting Requirements. An austere reporting approach has been emphasized repeatedly in the various 5000 reissuances. The 1975 version, for example, stated that "documentation shall be generated in the minimum amount to satisfy necessary and specific management needs." And the 1996 drafts[7] include a policy statement that "consistent with statutory requirements, program manag-

Table 1:
Number of 5000 Issuances per Administration

Administration	No. of Issuances
Nixon	1 (1971)
Ford	2 (1975, 77)
Carter	1 (1980)
Reagan	4 (1982, 85, 86, 87)
Bush	1 (1991)[8]
Clinton	1 (Just completed)

ers and other participants in the defense acquisition process shall be required to present only the minimum information necessary for decision authorities to understand program status and make informed decisions."

Program Stability. Program stability has also been a hardy perennial in the annals of defense acquisition policy. Nearly every issuance of the 5000 documents has made much of the importance of program stability. A good example comes from the 1987 version of the 5000.1, which stated that:

> Reasonable stability in acquisition programs is essential to satisfying identified military requirements in the most effective, efficient, and timely manner. Accordingly, program funding and requirements changes shall be minimized and shall not be introduced without assessing and considering the impact of such changes on the overall acquisition strategy and the established program baseline.

The 5000 Series: Policy Change

While there has been a remarkable degree of underlying stability in general principles, acquisition policy has changed over time. As shown in the summary table at the end of the paper, historically there have been two main catalysts for 5000 policy change. The first is a change in presidential administration. Every administration has issued its own version, and sometimes more than one. The Reagan administration, which held office for two full terms, issued four different versions of the 5000 documents, three of them in the three years between 1985 and 1987. Today, the Clinton administration is working on a new version (discussed in a later section).

What changes have been made in acquisition policy since the first version of 5000? A chart of the "course of policy change in chronological fashion" follows.

1975: A New Instruction. The first reissuance of 5000 was published in 1975 by Deputy Secretary William Clements. Differences in content between the 1971 version and the 1975 version were mini-

Table 2: DSARC and DAB Membership

DSARC (c. 1977)	DAB (Today)
Defense Acq. Exec., Chair	USD(A&T), Chair
Dir., De.f Res. & Eng.	Prin. Dep. USD(A&T)
ASD (Install & Log.)[9]	Vice Chair, JCS, Vice Chair
ASD (Comp.)	USD (Comp.)
Dir., Planning & Evaluation	Dir., Prog. Anal. & Eval.
Dir., Telecom. & C^2 Systems	ASD (Strat. & Res.)
	Comp. Acq. Execs.
Selected Advisors:	Overarching IPT Leader
Chairman, JCS	
DDR&E (Test & Evaluation)	***Selected Advisors:***
Chairman, Cost Analy. Impr. Group	ASD (Econ. Sec.)
Component Head	DUSD (Acq. Ref.)
	DUSD (Env. Sec.)
	DUSD (Log.)
	Dir., Def. Proc.
	Dir., Acq. Prog. Integ.
	Asst. Gen. Counsel (Acq. & Log.)
	Dir., Test, Sys. Eng., & Eval.
	Chair, Cost Analy. Improv. Group

mal. The big change in 1975 was the issuance of an accompanying instruction, DoD Instruction 5000.2, signed by Malcolm Currie, then-Director of Defense Research and Engineering.

The new instruction was narrowly focused, intended to establish "instruction guidelines governing the use of the Decision Coordinating Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC)." The DCP was to be summary document that would "support the DSARC review and the Secretarial decision-making process throughout the acquisition phase of the system program." Interestingly, this description of the DCP bears a close resemblance to the System Acquisition Management Plan (SAMP) now being instituted by the Air Force as a new streamlined means of presenting program information to top decision makers.

The new instruction only briefly referred to the DSARC. The membership of the DSARC and other administrative details were contained in the DSARC Charter, DoD Directive 5000.26. According to DoDI 5000.2 the DSARC was to serve "as an advisory body to the Secretary of Defense on major defense system acquisition programs and related policies." The DSARC was chaired by the DDR&E (DSARC and DAB memberships are compared in Table 2).

1977: A New Milestone. Institutionalizing policy change literally at the last minute, the Ford administration issued a new set of 5000 documents on Jan. 18, 1977, just two days before Jimmy Carter's inauguration. This time, Deputy Secretary William Clements signed 5000.1 and 5000.2, both of which were issued that year as directives. The reason was that this version of 5000.2 cancelled the separate DSARC Charter and included DSARC membership and responsibilities in the body of the instruction. The new documents were the product of several years of work. Several important events contributed to the formulation of the 1977 version, including the recommendations of the Commission on Government Procurement, the establishment of the Office of Federal Procurement Policy, and the issuance of OMB Circular A-109.

The major change evident in this version was the addition of a new milestone decision point. The 1971 and 1975 versions had described three major decision points: program initiation, full-scale development, and production and deployment. The 1977 issuance described a new decision point and corresponding phase: demonstration and validation. This addition was part of a continuing trend to concentrate management effort on reducing technical risk early in a program's lifecycle before initiation of full scale development. Of course, the late 1970s were a period of heightened Cold War tensions between the U.S. and the U.S.S.R. United States defense acquisition policy during this period was to respond to the Warsaw Pact's overwhelming quantitative advantages by pursuing ever more advanced technological solutions to mission needs.

The 5000 documents described the new decision as follows:

> When the DoD Component completes the competitive exploration of alternative system concepts to the point where the selected alternatives warrant system demonstration, the DoD Component Head shall request approval to proceed with the demonstration and validation effort.
>
> The DoD Component Head may conclude that the demonstration and validation phase should involve several alternatives, be limited to a single system concept, or involve alternative subsystems only and not be conducted at the system level. [The Component Head could also conclude that] there should be no demonstration and that the program should proceed directly into full-scale engineering development.

Other important changes made in the 1977 version included explicit direction to the Service Secretaries to "charter a System Acquisition Review Council similar in composition, responsibilities, and operation to the DSARC to review major system acquisition programs and to advise the Service Secretary." The "SARC" was to be chaired by the Service Secretary or Under Secretary. Given the contemporary focus on interorganizational teamwork, it is interesting to note that the 5000 provided that "upon request of the SARC Chairman, the Defense Acquisition Executive shall designate a senior OSD staff official to participate in the SARC."

1980: Focusing on Cycle Time and Adding More Detail. The Carter administration version of the 5000 is notable for several reasons. First, it included a discussion of several important concepts, including acquisition time and the interaction between the acquisition process and budget process. According to the 1980 5000.1, a "primary objective of management shall be to minimize the time it takes to acquire materiel and facilities to satisfy military needs. Particular emphasis shall be placed on minimizing the time from a commitment to acquire an operable and supportable system to deploying it with the operating force." To reduce cycle time, the 5000 authorized Components to explore various alternatives, including experimental prototyping of critical components, combining phases, or even omitting phases altogether.

Second, the 1980 version greatly expanded the descriptive nature of the 5000.2 instruction. For example, the instruction included an 8-page enclosure that listed "DoD policy issuances related to the acquisition of major systems." This enclosure was quite detailed, listing such documents as the Defense Acquisition Regulation, DoD Directive 5000.23, *System Acquisition Management Careers*, DoD Directive 4105.62, *Selection of Contractual Sources for Major Defense Systems*, and DoD Instruction 7000.11, *Contractor Cost Data Reporting*. The 1980 version also included detailed descriptions and formats for required documentation, such as the DCP.

Third, the 1980 version added a new document to the list of reports required at major milestone reviews. The new document was the Integrated Program Summary (IPS), which is still in use today (current changes in documentation are discussed in the last section of the paper). According to the 1980 5000.2, the purpose of the IPS was to summarize "the implementation plan of the DoD Component for the life cycle of the system. The IPS provides information for a management overview of the entire program."

Finally, the 1980 version described the new position of "DSARC Executive Secretary." According to 5000.2, the "Defense Acquisition Executive shall designate a permanent Executive Secretary who shall administer and coordinate the DSARC process." In addition, the DSARC Executive Secretary would be responsible for maintaining and distributing periodic status reports, assembling and distributing necessary documentation, maintaining a central reference file of program documentation, and controlling attendance at the DSARC.

1982: Implementing the Carlucci Initiatives. The main impetus driving the issuance of the 1982 revisions was the establishment of the Defense Acquisition Improvement Program (DAIP), better known as the "Carlucci Initiatives," after then-Deputy Secretary Frank Carlucci. The DAIP, which had been launched by Carlucci shortly after the Reagan administration took office in early 1981, was a comprehensive reform effort aimed at improving numerous aspects of the defense acquisition process. The DAIP consisted of 32 management initiatives, ranging from multiyear procurement and economic production rates to design-to-cost and linking acquisition and budgeting.

The 1982 revisions reflected many of the DAIP's themes. As Carlucci stated in a cover memorandum, "The attached Directive has been revised to reflect the principles and policies of the Acquisition Improvement Program." Many of these principles were particularly evident in 5000.1:

> Improved readiness and sustainability are primary objectives of the acquisition process.... Reasonable stability in acquisition programs is necessary to carry out effective, efficient, and timely acquisitions. To achieve stability, DoD Components shall conduct effective long range planning, consider evolutionary alternatives, estimate and budget realistically, [and] plan to achieve economical rates of production.

The 1982 version also made a change in milestone documentation, replacing the Mission Element Need Statement (MENS) with the Justification for a Major Systems New Start (JMSNS). The primary objective of this change was to more closely link the mission need determination process with the resource allocation process. As 5000.1 stated, "The mission need determination is accomplished in the PPBS process based on a Component's JMSNS which is submitted with the Program Objectives Memorandum (POM) in which funds for the budget year of the POM are requested."

1985–86: Responding to the "Horror Stories." Near the end of President Reagan's first term, procurement "horror stories" began cropping up with alarming regularity in the major media. As J. Ronald Fox has written:

> In the mid-1980s, an atmosphere of uncertainty, frustration, and apprehension pervaded the Pentagon and its contracting base, for each new day brought with it additional regulations and concerns that more errors would be uncovered by either the press or congressional auditors, investigators, and overseers. By 1986, the logjam of procurement legislation awaiting implementation had become so great that the Pentagon and defense industry officials pleaded with Congress for a moratorium on further reform legislation. (Fox, 1988)

The most significant change in the 1985 version designed to respond to procurement "horror stories" was the naming of the Deputy Secretary as the "Defense Acquisition Executive." Appointment of a single acquisition executive was a signal to Congress that the Pentagon was taking acquisition management seriously (although clearly the Deputy Secretary was not a "full-time" acquisition executive, since he spent a good deal of each working day on other matters not related to acquisition).

1987: Implementing the Packard Commission. In 1987, Congress and the Pentagon both began an intensive campaign to respond to the major recommendations of the Packard Commission. President Reagan had chartered this blue ribbon commission in 1985 to examine ways to improve defense management in general, and defense acquisition specifically. The commission made several important recommendations: Among other things, the commission suggested the establishment of a new full-time political appointment in OSD, an Under Secretary of Defense for Acquisition (USD(A)) who would have wide-ranging powers to supervise acquisition throughout the entire Department. The commission also recommended the institutionalization of baselining weapons programs to ensure a corporate commitment to key cost, schedule, and performance objectives.

Congress responded to the Packard recommendations very enthusiastically and, in short order, enacted the Defense Acquisition Improvement Act of 1986, which created the new USD(A) position. President Reagan nominated Richard Godwin, an executive with the Bechtel Corporation, to take the new job of acquisition czar. Within a few months of his confirmation, Godwin initiated another revision of the 5000 series documents, a revision which proved to be very controversial and ultimately played a starring role in Godwin's resignation after less than a year in the job.[10]

The 1987 documents contained several major changes over previous versions. First, they codified the new streamlined acquisition chain of command. This chain of command had been another major Packard recommendation. The new chain ran from the Program Manager through a Program Executive Officer to the Acquisition Executive of the military department. For selected major programs, of course, the chain went one link further to the new USD(A), who functioned as the Department's Acquisition Executive. Previously this position had been held by the Deputy Secretary.

Second, the 1987 documents established a new system of committees to support the operation of the Defense Acquisition Board (DAB).[11] According to the 1987 DoDI 5000.2, the committees were to "provide assistance in program review and policy formulation." The committees included three which focused on programmatic matters: strategic systems, conventional systems, and C^3I systems, and seven others that were designed to focus on broader policy issues. Among the latter set were science and technology, nuclear weapons, and international programs. The catalyst for the creation of these committees was Richard Godwin's frustration with the number of standing boards and councils that reported to him as USD(A). One count went as high as 126 separate boards and councils under his jurisdiction, many of them not directly related to acquisition. Godwin saw the DAB committee system as a means of consolidating his management structure and streamlining his span of control. Ironically, only the three programmatic committees exist today (now reconstituted as Overarching Integrated Product Teams); the policy-oriented committees never took root in the acquisition bureaucracy.

Third, the 1987 documents established two new milestones: Milestone IV and Milestone V. Milestone IV was designed to be a review one to two years after initial deployment to assure operational readiness and support objectives are being achieved and maintained during the first several years of operation. Milestone V was defined as a review, 5 to 10 years after initial deployment, of a system's current state of operational effectiveness and suitability to determine if major upgrades are necessary. Both post-production milestones were added to the 5000 in response to long-standing criticisms that the acquisition system paid too little attention to the life-cycle implications of new systems. The theory was that the institutionalization of formal decision reviews in the trans- and post-production periods would force the Department's acquisition leadership to continue to focus on the progress of weapons systems after a successful Milestone III, and to evaluate the possibilities for system life extension improvements in lieu of costly new acquisition programs.

1991 and 1996: What a Difference Five Years Make

The 1991 and 1996 revisions of the 5000 documents are easily the most far-reaching changes enacted since the 5000 was originally published in 1971. The 1991 documents represented a dramatic centralization of policy control and procedural specificity. And the 1996 version represents an equally dramatic reversal of these elements! The following section analyzes these two issuances.

1991: Policy Overhaul. The 1991 revision was prompted by Secretary of Defense Dick Cheney's 1989 Defense Management Report (DMR) and resulted in two revised issuances, DoDD 5000.1, "Defense Acquisition," DoDI 5000.2, "Defense Acquisition Management Policies and Procedures," and a new DoD 5000.2-M Manual, "Defense Acquisition Management Documentation and Reports." The DMR criticized the acquisition management system as being undisciplined and overburdened by regulation and made many specific recommendations for improvement. The 1991 documents were a concerted effort to respond to the DMR critique.

There were four main objectives of the 1991 overhaul (Sylvester, 1991). The first goal was to create a uniform system of acquisition policy by consolidating OSD guidance in one set of documents and enforcing a "no-supplementation" rule that barred the Components from supplementing the 5000 guidance with their own policy initiatives.

The second objective was to discipline the acquisition management process by articulating very clear (and, as some critics argued, rigid) guidelines for how programs should proceed through the acquisition life cycle, and by providing specific requirements for program documentation.

Third, the 1991 documents were an attempt to streamline the acquisition regulatory regime. This was to be accomplished by consolidating and cancelling numerous DoD directives, instructions, and policy memoranda that had previously been issued separately. More than 50 such documents were cancelled and their salient content combined into the new 5000 issuances. Examples include an August 5, 1988, Deputy Secretary policy memorandum on "Computer-Aided Acquisition and Logistics Support," DoD Directive 4120.18, "The DoD Metrication Program," and DoD Instruction 7220.31, "Unit Cost Reports." In most cases, much of the substantive content of these documents was retained.

The fourth and final aim of the 1991 rewrite was to address a litany of common complaints. Some of the most often voiced complaints were that the decision process was cluttered with too many people and offices and that many of these officials openly operated as "advocates" capable of exercising "veto" power over a program's progress if their unique demands weren't met.

The 1991 version reflected several major changes. First, the 5000.2 was now applied to *all* acquisition programs, not just major programs. This was a significant departure from previous practice, under which the procedures spelled out in the 5000.2 were intended for specific application only to major programs. (Since the first Packard edition, the 5000.1, on the other hand, has always stated general policies intended for application to all acquisition.)

Second, the documents created a new set of four acquisition categories, or "ACATs," which characterize a program's risk, complexity, and level of management authority. ACAT I programs are major programs, as defined in Title 10.[12] ACAT II programs are smaller programs that meet the statutory criterion for "major systems."[13] ACAT IIIs and IVs are still smaller programs, whose proper level of management authority is determined by the Component.

Third, the 1991 documents were the most comprehensive in 5000 history in terms of guidance and information provided to the field. The three documents—5000.1, 5000.2, and the manual—spanned over 900 pages in length. No other version of the 5000 documents since 1971 ever exceeded 60 pages. In part, this increase in volume was due to the consolidation of numerous directives and instructions that formerly had been issued as separate documents. The increase was also due to a deliberate attempt to provide as much specific information as possible on subjects such as decision criteria, key phase activities, and document formats.

In sum, the underlying shift in 1991 was a transition from a personal interaction among OSD, the Components, and program offices to a more formalized report-based interaction in which all necessary information would be transmitted in writing. This basic shift has now been reversed by the new 1996 documents, which are discussed next.

1996: Institutionalizing Acquisition Reform. Today, the Department is again revising the 5000 series documents. At this writing, the new 1996 version has just been completed and is being forwarded to the Secretary of Defense for final approval. The 1996 version was prepared by a joint working group, which consisted of representatives from OSD, the military departments, and the Defense agencies, and was co-chaired by the Deputy Under Secretary of Defense (Acquisition Reform) and the Director, Acquisition Program Integration.[14]

There are four principal objectives underpinning this most recent rewrite. First, this revision seeks to clearly separate mandatory policies and procedures from *discretionary* practices. The intent is to free managers to exercise sound judgment when structuring and executing defense acquisition programs.

Second, the new version incorporates into the 5000 series new laws and regulations that have been enacted since the last update. These include the Federal Acquisition Streamlining Act of 1994 and numerous policy memoranda issued by DoD acquisition officials, including new policy documents issued to implement acquisition reform recommendations.

Third, the latest edition consolidates, for the first time ever, acquisition policy guidance for weapon systems and automated information systems. Historically, the Department has treated these two classes of acquisition programs separately in terms of policies and procedures. Several separate AIS policy documents in the 7920 and 8120 directive and instruction series will be cancelled.

Finally, this revision is intended to respond to a growing perception that the current 5000 documents are unwieldy and too complex. To make the documents more "user-friendly," the final documents will be incorporated into the forthcoming Defense Acquisition Deskbook. The Deskbook will be the universal electronic and hard-copy repository of all DoD mandatory direction and discretionary guidance.

The new 1996 documents institute several major changes. First, while the new DoD Directive 5000.1 specifies guiding principles for all acquisition programs across the Department, the new regulation (more below on the switch to a "regulation") 5000.2 only applies to major programs. This reverses the scope of the 1991 5000.2. The intent of this change is to decentralize acquisition practice as much as possible and allow Component Acquisition Executives more of a hand in managing the programs for which they are being held accountable.

Second, the 1996 5000.1 articulates several new guiding principles that reflect how the department's acquisition system is responding to the larger changes in the global security environment wrought by the end of the Cold War. For example, one of the new policy principles stresses the importance of "nontraditional acquisition":

> The Department must be prepared to plan and execute a diverse variety of missions. To meet the user's needs in a timely manner, the acquisition system must be able to rapidly insert advanced technology directly into the warfighter's arsenal. Doing so means being able to demonstrate new and improved military capabilities on a scale adequate to establish operational utility and affordable cost. Demonstrations based on mature technologies may lead to more rapid fielding. Where appropriate, managers in the acquisition community shall make use of non-traditional acquisition techniques, such as Advanced Concept Technology Demonstrations (ACTDs), rapid prototyping, evolutionary and incremental acquisition, and flexible technology insertion.

Other new policy principles include modeling and simulation, innovative practices, and Cost As an Independent Variable (CAIV).

Third, the 1996 version moves away from the 1991 document's report-based interaction model. The 1996 version explicitly relies on Integrated Product Teams (IPTs) to break down the barriers between different organizations and acquisition disciplines and encourage integrated solutions to management problems. Moreover, the 1996 version cancels numerous report formats previously mandated by the 1991 documents (see Table 3). The focus in the new 5000 is on assembling the proper information for decision makers; the specific packaging and formats of this information is treated as an issue of secondary importance.

Fourth, at this writing, OSD leadership is considering a new method for updating the 5000 documents. As this article has shown, the traditional approach has been to engage in a "full-court press" of Herculean proportions every several years to update policy and practice. Now, to make the policy more of a dynamic representation of the areas currently being emphasized by the Department's leadership,

Table 3:
Report Formats in the New 5000

Specifically Mandated	Format No Longer Cited
Consolidated Acquisition Reporting System Operational Requirements Document Test and Evaluation Master Plan Live Fire Test and Evaluation Major AIS Quarterly Report	Mission Need Statement Integrated Program Summary (Includes Acquisition Strategy Report) System Threat Assessment Report Manpower Estimate Report Cost and Operational Effectiveness Analysis LRIP Report for Ships/Satellites Value Engineering Report Program Deviation Report MYP Contract Certification Fixed Price Contract Certification

one proposal under consideration is to use a standing board,[15] chaired by OSD and including representatives of the military departments, to vet policy proposals and authorize their inclusion in the 5000 documents. The chief advantages of such an approach would be to instill more discipline into the policy-making process and to avoid such long lag times between the initial articulation of a new policy and its ultimate institutionalization in the 5000 series.

Conclusion

The 5000 series documents are a unique window that allow us to see both the stability and change evident in defense acquisition policy over the last 25 years. While it is easy to criticize the fairly frequent changes in the 5000 documents over the years as evidence of a Department unclear about how it wants to proceed, there is a more optimistic (and, I would argue, realistic) view. The evolution of the 5000 documents reveals a Department sensitive to changes in its environment and quite willing to adapt its internal procedures to respond to this environmental turbulence.

In the early 1970s, as the Vietnam drawdown began, the Department's leadership took action to ensure a disciplined approach for managing acquisition in the post-Vietnam era. In the mid-1980s, the Department moved to institute several policy changes in response to the Packard Commission and the acquisition improvement legislation it spawned. And finally, in the 1990s, the Department has moved, first, to consolidate an acquisition policy system that had grown out of control, and second, to "deconstruct" this consolidated mass into a minimal set of mandatory principles and procedures that provides managers the greatest possible discretion. In each of these policy eras, the 5000 has been the primary vehicle for change.

The 5000 Series in Historical Perspective

Indicators	1971	1975	1977	1980	1982
Who Signed It?	• David Packard	• William Clements (5000.1) • Malcom Currie (5000.2) (plus other DSARD members)	• William Clements (5000.1 and 5000.2 - both were issued as DoDDs that year because the DSARC charter was *included in 5000.2)*	• W. Graham Claytor (5000.1 and 5000.2	• Frank Carlucci (5000.1) • Paul Thayer (5000.2 - actually issued in 1983)
Title	• Acquisition of Major Defense Systems (5000.1)	• Acquisition of Major Defense Systems (5000.1) • The Decision Coordinating Paper and the Defense Systems Acquisition Review Council (5000.2	• Major Systems Acquisitions (5000.1) • Major System Acquisition Process (5000.2)	• Major Systems Acquisitions (5000.1) • Major Systems Acquisition Procedures (5000.2)	• Same as 1980
Catalyst for Insurance	• Demonstrating to Congress a credible management system • Responding to Vietnam-era drawdown	• New administration • Issuance of New DoDI 5000.2	• Implement OMB A-109 • Institutionalize changes before Carter administration took office	• Change of administration • Emphasize need to reduce cycle time and to correlate acquisition decisions with PPBS	• Change of administration • Implement Carlucci Initiatives and Defense Acquisition Improvement Program
Major Changes	• n/a	• Minimal changes to 5000.1 • Included references to 19 DoDDs and DoDIs	• DSARC Charter included in 5000.2 • Both documents issued as DoDDS • Added Dem/Val milestone • Directed establishment of Service-level "SARCs" • Added Definitions section	• Separate discussion of affordability, acquisition time, and tailoring • Added new milestone documentation and included administrative details such as a pre-DSARC countdown • Called out "Secretary of Defense Decision Memorandum" as official document	• More explicit language on program stability, realistic budgeting, economic production rates, and evolutionary acquisition strategies • Justification for Major Systems New Starts replaces MENS
Major Milestones	• Program Initiation • Full Scale Development • Production and Deployment	• Program Initiation • Full Scale Development • Production and Deployment	• Program Initiation • Demonstration/Validation • Full Scale Development • Production and Deployment	• Program Initiation • Demonstration/Validation • Full Scale Development • Production and Deployment	• Program Initiation • Demonstration/Validation • Full Scale Development • Production and Deployment (delegated to Component)
Format Milestone Documentation	• Decision Coordinating Paper (DCP)	• DCP	• Mission Element Need Statement (MENS - for Milestone 0) • DCP	• MENS • DCP • Integrated Program Summary (IPS)	• JMSNS • System Concept Paper (SCP) • Test and Evaluation Master Plan • DCP • IPS
References	• 14 (not clear if all 14 were actual documents	• 23	• 29	• 136	• 37
Page Count (including DoDI)	• 7	• 14	• 33	• 60	• 38

The 5000 Series in Historical Perspective

Indicators	1985	1986	1987	1991	New 1996 Version
Who Signed It?	• William Howard Taft (5000.1 and 5000.2)	• William Howard Taft (5000.1 and 5000.2)	• William Howard Taft (5000.1 and 5000.2)	• Donald Atwood • Donald Atwood and Robert Duncan	• William Perry • John White
Title	• Same as 1980	• Same as 1980	• Major and Non-Major Defense Acquisition Programs • Defense Acquisition Program Procedures	• Defense Acquisition • Defense Acquisition Management Policies and Procedures • Defense Acquisition Management Documentation and Reports	• Defense Acquisition • Mandatory Procedures for Major Defense Acquisition Programs and Major Automated Information Systems
Catalyst for Insurance	• Respond to procurement "horror" stories • Demonstrate that top officials were paying attention to acquisition system	• Reflect establishment of new Director of Operation Test and Evaluation (DOT&E) and associated reporting requirements	• Implement Packard Commission and related acquisition improvement legislation • Reflect establishment of new Under Secretary of Defense for Acquisition • Emphasize that 5000 acquisition policies apply Department-wide	• Change of administration • Implement Defense Management Report	• Institutionalize acquisition reform efforts • Implement Reinventing Government initiatives • Integrate policy for weapon systems and automated information systems
Major Changes	• Named Deputy Secretary as "Defense Acquisition Executive" • Reflected new ASD (Acquisition and Logistics) as Milestone III DSARC chair	• Includes discussion of DOT&E as member of DSARC • Includes discussion of content and timing of the Beyond-Low Rate Initial Production (B-LRIP) report	• Includes discussion of USD(A) • Breaks major programs into two categories: DAB and Component • Includes discussion of Program Baselines	• Consolidation of over 50 Directives, Instructions, and policy memoranda into a unified set of acquisition guidance • Application of 5000.2 procedures to all Acquisition Category programs • Creation of a Manual specifying detailed formats and procedures for acquisition reports	• Deletion of substantial volume of guidance formerly treated as mandatory • New guiding principles on Non-Traditional Acquisition, IPPD, and Innovative Practices • Institutionalization of IPTs and IPPD • Deletion of numerous report formats
Major Milestones	• Same as 1982 version	• Same as 1982 version	• Milestone 0, Concept Exploration and Definition • Milestone I, Demonstration and Validation • Milestone II, Full Scale Development/Low Rate Initial Production • Milestone III, Full Rate Production and Initial Deployment • Milestone IV, Review Readiness and Support • Milestone V, Upgrade or other Replacement Action	• Same as 1987 except for deletion of Milestone V	• Same as 1987 except for - Deletion of Milestone V - Treatment of LRIP as a separate decision point that may be held after the Milestone II decision

The 5000 Series in Historical Perspective

Indicators	1985	1986	1987	1991	New 1996 Version
Formal Milestone Documentation	• Same as 1982 version	• Same as 1982 version plus the B-LRIP report	• Mission Need Statement • Cooperative Opportunities Document • *System Concept Paper* • Test and Evaluation Master Plan • Cost and Operation Effectiveness Analysis • Common-Use Alternatives Statement • Program Baseline • Independent Cost Estimate • Decision Coordinating Paper • Acquisition Strategy Report • Beyond-LRIP Report • Manpower Estimate Report	• Same as 1987 with the following changes: - *Several documents formerly* treated in separate regulations, such as the Operational *Requirements Document and* System Threat Assessment Report, were now discussed in the new *5000.2-M* Manual - The SCP, DCP, and Common-Use Alternatives Statement were deleted	• Same as 1991 with the following changes: • *Mandatory formats* only specified for CARS, ORD, TEMP, LFT&E, MAIS Quarterly Report
References	• 38	• 38	• 54	• 152 (does not include the documents that were cancelled)	• 64 (does not include the documents that were cancelled)
Page Count	• 42	• 40	• 38	• app. 900 (includes both the Manual and Change I published in February 1993)	• 160

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END NOTES

1. The author would like to acknowledge the kind assistance of several colleagues, including David Anderson, Fred Reinhard, John Smith, and Ric Sylvester.

2. The reader should note that before the 5000 series, DoD had relied on the 3200 series to articulate defense R&D and procurement policies and procedures. For example, Secretary of Defense Robert McNamara issued DoD Directive 3200.9, "Initiation of Engineering and Operational Systems Development," in July 1965.

3. The Secretary, Director of Defense Research and Engineering, and the Assistant Secretary for Telecommunications. It is interesting to note that the first 5000 distinguished between acquisition programs under DDR&E's cognizance and those programs under the jurisdiction of the ASD(Telecommunications). Twenty-six years later, the names have changed but the Department is still wrestling with this division of labor.

4. Then defined as "programs which have an estimated RDT&E cost in excess of 50 million dollars or an estimated production cost in excess of 200 million dollars."

5. Limited reporting, of course, continues to be a major concern today.

6. Please note that this table is a summary and is not intended to provide a complete description of each document.

7. As of this writing, USD(A&T), DOT&E, and ASD(C^3I) have approved the 1996 final drafts and forwarded them to the Secretary of Defense for final approval.

8. An update was published in February 1993, right at the beginning of the Clinton administration, but this was really only an administrative change, not a formal reissuance of the directive and instruction.

9. The reader should note that the old ASD(I&L) organizations had broad responsibilities, to include both production and contracting issues.

10. During the final stages of the 1987 5000 revision, Mr. Godwin complained that higher officials had revised key sections of the documents to dilute his statutory authority. A point of particular contention was the replacement of the word "establish" with the word "develop" in a sentence stating that a primary role of the USD(A) was to "establish" acquisition policy for the Department.

11. The DAB was the new name for the DSARC, which had been temporarily renamed the Joint Requirements and Management Board during 1986.

12. 10 USC 2430.

13. 10 USC 2302.

14. It is worth noting that this working group method is a departure from previous practice. Many (but not all) previous 5000 rewrites were developed by small teams of OSD officials and then coordinated with the rest of the Department.The 1996 version was developed jointly by a working group that included over 20 representatives of the Department's acquisition organizations.

15. One candidate for this standing board is the Joint Functional Team (JFT), which was established in 1995 to oversee the operations of the Defense Acquisition Deskbook. The JFT is co-chaired by the DUSD(AR) and the D, API.

TRANSATLANTIC COOPERATIVE WEAPONS DEVELOPMENT: HOW CAN WE BETTER ENSURE SUCCESS?

Davi M. D'Agostino

This paper evaluates and compares two multinational weapons development efforts: a cancelled program (Multiple Launch Rocket System Terminal Guidance Warhead) and a new program (Medium Extended-Range Air Defense System). The research identifies multinational political and management issues that exacerbated technical and schedule problems. Risk areas include: number of countries and industries; differing and excessive requirements; cost share and technical work share decisions; consortia versus prime contractors; and international program office staffing and decision making. The paper makes concrete recommendations to improve potential for success in the new program.

For decades, the United States and its allies have spent billions of dollars on collaborative weapons development projects that have generally eluded success. This is a puzzling phenomenon: the main objectives of cooperative weapons funding and development are to eliminate costly, competing, duplicative programs, and to pool requirements, funding, and talent to develop affordable, interoperable systems. These programs also have a fundamental political objective of cementing relationships—which tend to be stressed when multinational programs fail. Many observers attribute program failures to the lack of political support, priority, advocacy, and multiyear funding. But very few have taken a cold, hard, deep look at problem programs to identify key causes and improve the next program.

All weapons development efforts entail some level of cost, schedule, and technical risk—if they don't, they don't represent enough advancement in capability or technology to be worth pursuing. My research examined the canceled, four-nation Multiple Launch Rocket System Terminal Guidance Warhead (MLRS/TGW) program to identify some of the key political and administrative issues that added to its cost, schedule, and technical problems.

If the MLRS/TGW's schedule had not slipped more than six years, it could very well be continuing today as a good example of cooperative development. After the program was canceled, flight tests successfully demonstrated the MLRS/TGW met its objectives as a robust tank-killing sub-munition. Had the MLRS/TGW come closer to its originally scheduled initial production (April 1989), it certainly could have been selected as the U.S. Army's submunition of choice.

Using MLRS/TGW as a baseline, I examined the same aspects of the prospective four-nation Medium Extended-Range Air Defense System (MEADS) to identify similarities and differences. At the time of this writing, a MEADS Memorandum of Understanding had not been signed and was not available for analysis. In addition, the infancy of the MEADS program did not allow full comparison with many critical aspects of the MLRS/TGW program. At the same time, however, this represents a great opportunity for MEADS to benefit from the MLRS/TGW experience.

From the research, a mosaic of uniquely multinational political and administrative/management issues emerged to explain many problems that contributed heavily to difficulties in the MLRS/TGW program. At least in theory, these problems could be avoided or mitigated for future programs, including the MEADS. An overall theme emerged: for success in multinational programs that have been well-selected, *national political issues and pride need to be subordinated to what is best for the program.* The main goal—to develop and produce a multinational weapon system that meets operational requirements on time and at a reasonable cost—must always be the driver. It is difficult enough to overcome technological and other program challenges without the unique complexities of successfully managing a multinational development effort.

Some limitations to the research are noteworthy. The ingredients for success identified were not based on an examination of a successful program. Moreover, experience in one program may not always be applicable to another program, as each multinational development effort is unique in many ways. Finally, there is no guaranteed prescription for success, as many more variables than were examined here have important effects on a weapon development effort.

The Environment for Transatlantic Cooperation

Many ongoing and new codevelopment programs have been managed in an environment fraught with tensions among political pressures for pan-European versus transatlantic cooperation, and each nation's sharpened concerns over the survival of their defense industries. In the mid-1980s, Europe made great political strides for pan-European cooperation in weapons development. NATO's Confer-

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ence of National Armaments Directors established the Independent European Programme Group to press for European Community-style defense cooperation. Since weapons procurement was not in the European Commission's purview, the Independent European Programme Group served as the forum for cross-border weapons collaboration and procurement in Europe.

At the same time, in an effort to gain potential savings and interoperability from codevelopment efforts and rise above a United States–only approach to weapons development and production, the Congress passed the Nunn–Quayle amendment to the Arms Export Control Act (1985) to promote transatlantic cooperation. The "top down" approach—making money available for cooperative ventures—led to a proliferation of low-priority, two-year efforts that were not continued. A number of other larger transatlantic cooperative programs, such as the North Atlantic Treaty Organization (NATO) Frigate, fell apart for various reasons, including the inability to agree on requirements.

After the Berlin Wall fell and the Soviet Union dissolved, the U.S. and European defense industries began more rapidly and radically transforming through mergers, acquisitions, and downsizing to respond to the new realities. On both sides of the Atlantic, defense spending became more constrained while weapons program costs increased. Also, concerns about losing critical national defense production capabilities and jobs were on the rise.

In the first half of the 1990s, the Independent European Programme Group was moved from NATO auspices to the Western European Union—a European defense organization with no U.S. participation. France apparently took the lead in pressing for intra-European cooperation, sometimes in competition with potential transatlantic ventures. France continues to see itself as the defense technological and industrial leader in Europe—in direct competition with the United States. At the same time, U.S. Defense Secretary Perry called for a "renaissance" in cooperative weapons development with Europe. The MEADS is the showcase project of Secretary Perry's "renaissance."

The MLRS/TGW: A Good Cooperative Weapons Program That Could Have Gone Better

What Was the MLRS/TGW and What Happened? The MLRS/TGW was actually phase three of the multinational MLRS program. The objective was to develop a target-sensing submunition and warhead for attacking armored targets at distances up to 30 kilometers or more. It was to be launched from the MLRS rocket or from an Army Tactical Missile System.

In many ways, the program attempted to go well beyond the state-of-the-art. For example, it was to use a millimeter wave seeker. The United States had only once before attempted to develop a weapon system that uses a millimeter wave seeker, largely because of technical risk and cost. In fact, one person interviewed noted that the MLRS/TGW program would have benefited from some additional up-front substantive research on the seeker and certain other components, possibly during the concept definition phase.

Political pressures to get the international program started and under way overruled some program officials' desires to take this path to lower technical risk. Instead of performing additional research up front, the partners took a cautious three-stage development approach: a two-stage validation program (component demonstration and system demonstration) followed by a maturation and full-scale development stage. Figure 1 highlights key events in the MLRS/TGW program.

The concept definition phase began in September 1981, with competing multinational contractor teams, each with different companies from the United States, France, Germany, and the United Kingdom. The four governments signed a Memorandum of Understanding in late 1983. The governments' cost sharing was established in that agreement: The United States would fund 40 percent, and each of the European allies would fund 20 percent. In November 1984, the U.S. Army awarded a cost-plus-incentive-fee component demonstration contract to the team with the best technical concept and the lowest bid—Martin Marietta (United States), Thomson CSF (France), Diehl GmbH & Co. (Germany), and Thorn EMI Electronics (United Kingdom).

In February 1989—two years behind schedule—the Defense Department approved the system demonstration substage for the MLRS/TGW, but with several conditions attached. The conditions were that the U.S. Army had to (1) do a cost and operational effectiveness analysis comparing the MLRS/TGW to alternatives for defeating the armored threat, (2) define specific actions to improve the ability to manufacture the submunition, and (3) prepare a test and evaluation master plan defining specific quantitative test goals for entering into full-scale development.

Over time, the program slipped and encountered many difficulties. During 1990, the MLRS/TGW competed with a previously classified U.S. program, the Brilliant Anti-armor submunition (BAT), and other systems in a U.S. Army "neckdown." In March 1991, the

CONCEPT DEFINITION PHASE BEGINS	SEPTEMBER 1981
GOVERNMENTS' MEMORANDUM OF UNDERSTANDING	LATE 1983
COMPONENT DEMONSTRATION SUBSTAGE CONTRACT AWARDED	NOVEMBER 1984
SYSTEM DEMONSTRATION SUBSTAGE APPROVED BY DOD	FEBRUARY 1989
SYSTEM DEMONSTRATION SUBSTAGE CONTRACT AWARDED	JULY 1989
U.S. ARMY SELECTS BRILLIANT ANTI-ARMOR SUBMUNITION OVER MLRS/TGW	MARCH 1991

Figure 1. Key Events in the MLRS/TGW Program

Army selected the BAT. The Congress would not permit continued funding of both MLRS/TGW and BAT, and the United States withdrew from the MLRS/TGW program.

Four Countries/Industries May Be Too Unwieldy. Experts on international programs agree that the complexity and difficulty of managing a successful international program increases by a high coefficient with each additional partner. The increased complexity in decision making with four partners of differing languages, political and acquisition systems, and cultures placed stress on the MLRS/TGW program and a drag on the schedule by all accounts. Program officials interviewed unanimously agreed that two or three partners in the MLRS/TGW would have been easier to manage and less costly. They also believed fewer partners would have been more efficient for the program in terms of technical performance, program management and decision making, administrative issues, and gaining agreement on the threat (discussed further below).

For example, the more partners, the more problems a program will likely have in tracking and managing cost shares and work shares—which can be critical to ensuring fairness in a multinational program. In the MLRS/TGW, the 40-20-20-20 cost share was tracked and managed in accordance with the Memorandum of Understanding. Under the agreement, exchange rate fluctuations and inflation in any of the countries affected the cost shares and work shares.

The program was also set up to adjust the work share to cost share on the basis of cost, largely to ensure equity. That is, if a company was performing a development task and began to substantially exceed the estimated cost of the work, that task or some other work it was performing on the program would be moved or subcontracted to another company on the team for completion. While this was a difficult process to implement, some former project officials noted this had a side benefit of helping identify companies having technical and cost problems and making adjustments to solve them.

Get Detailed Requirements Agreed to Up Front. The program got underway with only the most general agreement on the need for a tank-killing submunition for use behind forward lines of troops and a broad technical approach (e.g., millimeter wave seeker). One source observed that, when the four governments could not agree on the threat details, they ignored them and moved forward with the program. Throughout much of the component demonstration phase, the four nations continued to debate the specific characteristics of the threat—the Future Soviet Tank in the year 2000. As late as 1992, the U.S. Army operational requirements document for the MLRS/TGW remained in draft form.

Many programs during that period were dealing with an evolving threat. Two changes in the requirements negatively affected the program's already high technical risk and ambitious schedule. In the first case, the requirements changed due to a newly projected reactive armor threat. Early on, the United States and the United Kingdom believed the Future Soviet Tank would require the MLRS/TGW to have a more robust lethal capability than did Germany and France. This caused the program to switch to a more lethal submunition with a dual shape charge, and caused cost, schedule, and technical problems in the program. In the end, though, the U.S. and U.K. estimate of the tank changed to agree with that of France and Germany. The program, however, was already committed to the more lethal design.

While changing lethality requirements added time to the development schedule, another change affected the schedule even more severely. About halfway through the development effort, France and Germany raised a new requirement to overcome the effects of high reflectivity snow. This new requirement forced the program to add a backup seeker with Doppler beam sharpening to the development effort. This backup seeker also caused the team to design and develop another type of signal processor. It was a very high risk effort technically, and, in retrospect, the interviewees unanimously viewed it as unnecessary. One source had researched the historical occurrence of high reflectivity snow to find it only occurs in very few European theater locations for 5–6 days a year, in a narrow window of morning hours.

Select the Right Companies to Do the Right Jobs. As with many programs, much of the schedule slippage was caused by technical difficulties encountered by the contractors. The contractor teams that competed for the MLRS/TGW differed greatly in skill for the development tasks—particularly the European companies. The team that won on the basis of low bid included Diehl of Germany, an ammunition and cartridge producer, and Thorn EMI of the United Kingdom, an electronics firm. In retrospect, the interviewees agreed and the record showed that the best (most technically qualified and experienced for development tasks) German and British companies for the job were on the losing teams. While companies from all four countries encountered technical difficulties, Diehl and Thorn were the focus of most comments from the interviewees regarding causes for schedule slippage.

Nevertheless, the governments decided to use the same team that put together the winning bid and national political pride was put at stake. Having a team with some weaker members, alone, however, did not guarantee major problems. *The potential risk was compounded when the companies began dividing work share on the program.* Work share was not distributed on the basis of the companies' technological strengths and comparative advantage. Instead, development tasks were distributed on the basis of the work the companies (and their governments) *wanted to do* in the program. Moreover, they tried to get equality in the work shares—roughly 25 percent per company and country—in terms of quality. The quality factors for work shares were the technologies' position related to the state-of-the-art, potential importance to competitiveness, uniqueness, potential applications beyond the MLRS/TGW, and potential profitability.

The countries and companies fought over the most technologically attractive work shares—particularly the electronics. Their objectives were *not* what work share to take for the betterment of the program, but rather what work share would most advance their companies' competitiveness and capabilities. The Europeans won most of the critical electronics work. As a result, Diehl worked on electronics (e.g., flight computer and leading edge integrated circuits) and operational flight software development tasks it was unable to perform. During the program, Diehl essentially built these capabilities in its company from the ground up and at the program's expense. Most interviewees cited Diehl's poor performance on its flight computer and software development tasks as causing serious schedule slippage in the program. In retrospect, the U.S. and French were considered the best (most capable, causing fewest difficulties and delays) for the software development tasks—and the U.S. likely would have done the work at lower cost.

Another unfortunate decision made in the project was to allow the development work on critical components to be split among the companies. For example, the seeker development work was split up and spread among the four companies. This made integration and interface an even more complex task than it might have been. In addition, search and target detection software development tasks on the seeker were split between two companies (the United States and Germany), while the target tracking software development work went to a third (the United Kingdom).

One Production Line or Two?

The decision on a single final assembly and integration line was also afflicted by nationalistic politics. Initially, the partners agreed that all requirements would be served from one integration line in the United States, with the components coming from the other three countries' facilities. This made sense since the U.S. company's strength was in integration. In 1990, however, the European partners insisted on a second, European integration line, despite the likely quantity reduction in all the partners' requirements. One source noted that the Europeans pressed for a second production line because they wanted to freely make third country sales. However, the Memorandum of Understanding provided that sales or transfers outside NATO of articles developed in the project with the use of foreground data would require the unanimous prior approval of all participants. As a result, any sale of MLRS/TGW submunitions would require agreement of all the parties *in any case.* Another source noted that both the United States and the Europeans decided they wanted full production capability. Had the program reached the production phase, two lines would have essentially obviated any unit cost savings during the production phase—and would have added to all the partners' production costs.

Have a Prime Contractor—Consortia Are Not Optimal

Rather than assign one company the prime contractor role, the four companies formed a joint venture consortium—MDTT, Inc.—to sign the contract and provide overall management. The governments supported this approach mainly for financial reasons. A consortium would avoid the high overhead costs of a prime contractor being added to work being performed by the others.

While this was a good goal and approach from one cost control perspective, all interviewees agreed that the lack of a prime contractor on the program contributed to delays and technical issues. This was especially true given the cost-plus-incentive fee contract, which minimized government involvement, direction, and oversight. First, there was little accountability in the consortium, and decision making on work share was hampered by the lack of leadership in MDTT. In addition, there was no project management, planning, or risk analysis from the companies. The sources agreed that a prime contractor could have and would have selected the best companies for the development tasks, determined work share more on the basis of technological strengths of the companies, and better managed the contractor efforts.

Administratively, MDTT also encountered difficulties getting staffed out of the European companies, as did the European government complement in the international program office (discussed below). More than nine months after the component demonstration contract had been signed, MDTT still did not have a full contractor team in place.

Create a Fully-Staffed, Full-Fledged International Project Office

The MLRS/TGW had an international project office, but the French, German, and British liaison officers did not represent a full complement of "program office-level" decision makers from their countries and were not vested with deciison making authority. The European national program office personnel from these three countries made periodic visits to the project office, located at the U.S. Army Missile Command, for Technical Working Group meetings and other events. Another problem in project office staffing was the serious delay in getting even a limited European government complement in the international project office. In the case of one country, it took nine months of negotiation to get a liaison officer assigned and located in the office.

Some interviewees believed a greater team culture would have been established if all the principals had been located full-time in the international project office. They believed this would have resolved many of the language barriers, nationalistic pride issues, and decision making impediments the program encountered. A source also noted many problems could have been resolved informally in a full-fledged international project office setting (e.g., over lunch). Instead, the visits created a more formal, less congenial atmosphere for timely problem solving. "You need to live together so that your honor is not placed on the line when you disagree."

Another problem that might have been overcome early on had there been more of a true team culture was the limited sharing of "national assets" in this program. For example, one interviewee noted that the countries had some background data on technologies that were critical to MLRS/TGW success. The impression was that this data was not brought to the table and shared openly and honestly. Had this data been shared, and had the countries formed a more "seamless" team, many technical problems would have been more easily overcome. Again, in this vein, the interviewees emphasized the need to keep national and international politics out of the program decision making to the maximum extent possible, and focus energy and interests on doing what is best for the program's progress.

PARTNERSHIP AND CONSENSUS DECISION MAKING ARE GOOD AND BAD

While consensus decision making can be indicative of true partnership and equitableness for all players, it can also lead to problems and a more negative and time-consuming approach to reaching agreement. The MLRS/TGW program employed a consensus decision making process, with three levels of decision authority vested in multinational committees. The top level of decision making was the multinational Joint Steering Committee (flag officer level) which met semi-annually. The next level was the Executive Management Committee (program manager level) which performed cost, schedule, and performance oversight and met semi-annually. The next level—the first level of decision making—comprised the technical, cost, and test working groups, which included lab and program technical staffs who met quarterly. Disputes that could not be resolved at the lowest levels were escalated up the chain described above. The U.S.-based MLRS/TGW program office was the "residence" for liaisons from each country.

Several sources noted that getting an answer to a single question sometimes took months. In addition, U.S. government personnel and contractors found that problems they normally solved in one meeting took three meetings. They also indicated that holidays and vacations, heavier for some partners than others, delayed progress in decision making. No program activity could be scheduled during the month of August, for example. Some sources noted that the European partners often united and "out-voted" the United States.

One interviewee characterized the decision making in the MLRS/TGW as "nominally consensus," but, in practice, it was a process based on threat of veto much of the time. When the parties could not reach full agreement on an issue, it was a matter of "who screamed and pounded the table loudest." If a party felt very strongly about an issue, they might threaten to veto a decision, which would stop the program. This sometimes resulted in a more negative approach to decision making rather than positive agreement and compromise.

THE MEADS PROGRAM: WHAT PATH IS IT TAKING?

What is MEADS? And How Did it Become a Multinational Program? The U.S. concept of the MEADS program is that it is a multilateral extension of the joint U.S. Army–Marine Corps "Corps Surface-to-Air Missile" (CorpsSAM) begun in 1990. The MEADS is to provide a follow-on to the HAWK air defense system, initially developed in the 1950s and 1960s. It is also expected to replace the PATRIOT (Pac 3) system. It has been incorporated as a lower tier system into the Ballistic Missile Defense Organization (BMDO) approach to ballistic missile defenses. U.S. concepts state the system will be designed as an air-mobile system providing limited area and point defense to maneuver forces and critical support nodes against tactical ballistic missiles and air-breathing threats, including cruise missiles and unmanned aerial vehicles.

Technical and political issues appear to have driven the four countries to join in the MEADS program. While the U.S. concept definition for the CorpsSAM proceeded, Germany developed a concept for a HAWK follow-on. Germany completed its concept definition for its *Taktisches Luftverteidigungssystem*—TLVS or tactical air defense system—in 1991. In 1993, having defined the U.S. CorpsSAM concept, the U.S. Army Missile Command compared and evaluated the German and U.S. concepts, finding them nearly identical. This prompted early discussions of a joint United States–German effort along CorpsSAM lines. At the same time, France and Italy, uninterested in ballistic missile defense capability, were courting Germany for funding and participation in an upgraded SAMP-T, a Franco-Italian developed and produced air defense system.

In February 1994, the Deputy Secretary of Defense invited Germany to participate in the CorpsSAM program. By the spring and summer of that year, France objected to Germany's tilt toward transatlantic versus pan-European cooperation, and discussion between the United States and Germany ceased. In August 1994, U.S., German, and French principals decided to join forces on the MEADS. Concerned about having no role in such a major program that would compete with a SAMP-T upgrade, Italy joined in December 1994. In February 1995, the four countries signed a Statement of Intent to proceed with MEADS. The four nations negotiated a MEADS program Memorandum of Understanding for the first phase and expected to sign the agreement in early 1996. The United States is expected to fund 50 percent, France and Germany 20 percent each, and Italy 10 percent of the program costs.

The U.S. political and funding environment for the program is not completely supportive or secure. The key Congressional committees have serious, fundamental questions about whether or not the requirement for the CorpsSAM and now MEADS can be satisfied more cheaply and at lower risk with a hybrid of the PATRIOT (Pac 3) and the Theater High Altitude Area Defense systems, or with the range and altitude improvements being made to the HAWK system—HAWK III.

Affordability is a major issue with six ongoing ballistic missile defense programs. There are also concerns about "reinventing the wheel" in MEADS and not using pertinent technology from other programs well under way. During 1995, while the Defense Department was negotiating internationally on the MEADS program, Congressional committees completely cut fiscal year 1996 funding for the CorpsSAM. Congress then reinstated some funding after numerous letters of support came from key Defense quarters (CINCs, JCS, etc.).

Four Countries and Six Companies Will Be Involved

As in the MLRS/TGW program, MEADS involves four government partners in a highly complex development effort. MEADS also uses six-member contractor teams, versus the four-member MLRS/TGW team. During the first phase—Project Definition–Validation—two U.S. contractors and teams will be competing against each other. The two U.S. competitors will be linked with A and B teams from the same European companies. The European companies have formed a consortium called "Euro-

TEAM A	COUNTRY	TEAM B
HUGHES–RAYTHEON	UNITED STATES	LOCKHEED MARTIN
SIEMENS	GERMANY	SIEMENS
DEUTSCHE AEROSPACE	GERMANY	DEUTSCHE AEROSPACE
THOMSON CSF	FRANCE	THOMSON CSF
AEROSPATIALE	FRANCE	AEROSPATIALE
ALENIA	ITALY	ALENIA
SOURCE: DEPARTMENT OF DEFENSE, BALLISTIC MISSILE DEFENSE ORGANIZATION		

Figure 2.
Competing Teams for MEADS Project Definition–Validation Phase

MEADS." Figure 2 illustrates the arrangement envisioned for this phase.

With six companies involved, and the defense industrial stakes high for all four countries, MEADS will probably involve a higher degree of complexity and difficulty for program management as compared to the MLRS/TGW.

Full Agreement on Detailed Requirements Remains a Goal

The United States and Germany appear to have one set of requirements for MEADS, while France and Italy seem to have another. Critical issues, including the ballistic missile defensive capability of the system, remain unresolved between the U.S.–German requirements and the French-Italian requirements. The National Institute for Public Policy recently completed a study of the differing perspectives of MEADS among United States and European representatives, indicating a wide gulf between the two groups (United States–Germany versus France–Italy) on the military function of MEADS and its origins. The United States and Germany apparently are working from the U.S. CorpsSAM concept, adjusted for certain German-unique considerations. France and Italy, on the other hand, seem to be wedded to an upgraded version of the SAMP-T. This raises the risk that, France and Italy may leave the MEADS program and apply some MEADS technical concepts to their preferred European system. However, without German funding and participation, they are unlikely to be able to proceed. Germany appears to be pivotal to success for both the United States and European program concepts.

A critical test will come in the form of the Request For Proposal (RFP) that will be issued to the two industrial teams. The RFP presumably will be based on a NATO Supreme Headquarters Allied Powers Europe military operational requirements document that was drafted but, as of January 1996, not yet approved by the North Atlantic Council. The Request for Proposal must contain sufficient information on the operational requirements for the teams to provide the deliverables. According to Defense Department officials, the deliverables will be a set of specifications and a cooperative plan for developing and producing the system. This phase will also involve some limited hardware and simulation deliver-ables.

Will the Right Companies Do the Right Development Work?

Three U.S. teams were competing for the CorpsSAM program: a Hughes–Raytheon team, Lockheed Martin, and a Loral-TRW–Westinghouse team. The Loral team was eliminated from the competition in an October 1995 Defense Department decision. This left Hughes–Raytheon and Lockheed Martin to compete from the United States during the first phase of the MEADS program. According to Defense officials, the plan is to divide work share in accordance with cost share, as in the MLRS/TGW program.

How were the European companies selected to participate in the critical Project Definition–Validation Phase? One U.S. interviewee noted that the European companies were selected by their governments because they were the only ones that could do the development and production work at the system level. In any case, the approach of using two core teams from the same European companies seems to avoid one cause of problems encountered in the MLRS/TGW program. The "favorite" European companies apparently were selected up front. If they are the strongest technologically for MEADS those nations have to offer, the risk of technical problems affecting cost, schedule, and performance is reduced. In other words, there is no risk that weak contractors will participate in this phase of the program.

Still, the risks to success will be increased unless technical work share is determined truly on the basis of technological strengths and experience each company brings to the program. It is too early in the program to determine how technical work share will be divided among the companies in any detail. All the companies involved in the program appear to be experienced and capable for certain development tasks. The U.S. companies are already involved in the PATRIOT and Theater High Altitude Area Defense programs. Siemens is a premier communications company, making it likely to be heavily involved in the battlefield management center concept for the MEADS. Deutsche Aerospace, Thomson CSF, Aero-spatiale, and Alenia are engaged in various European national and cooperative missile programs.

One source noted that the draft Memorandum of Understanding (MOU) will provide that the work share will be equivalent to the cost share, that this will be based on fixed, negotiated exchange rates as reference points for calculating work-share value, and that work-share calculations will be determined to the second tier on a nation-by-nation basis. This is similar to the MLRS/TGW program. What is different is that the agreement would allow work share at the second tier to be subcontracted across nations with approval of the steering committee. This provision would be used, for example, if a particular company could not perform its work share. If not carefully managed, though, it is possible that from a given country's perspective, it may not ultimately get a work share commensurate with its cost share. The agreement essentially provides that since the program will use a fixed price contract, any cost overruns presumably will be absorbed by the company that experiences them.

As experience in the MLRS/TGW program showed, technical work shares should not be determined primarily on the basis of their desirability and equitability, but rather on the basis of the companies' *current* technological strengths and capabilities. In short, *work shares should not be driven by what will be best for the companies' development, but by what will be best for the program and the system's development.* This is not to say that work shares should not be determined—to the greatest extent practicable—with fairness in terms of desirability and cost shares.

According to one interviewee, production work shares will pose the most difficult problem. For example, the contractor(s) who have integration and software tasks during the development program will need more in production work to ensure equitableness. As a result, some companies who designed and developed hardware in the program will have to give up a piece of the production work to others. Program officials believed, however, this was a workable issue, as the stakes are high for all the partners to make this program successful.

The political posturing and mistrust over who gets quality MEADS technical work shares, however, appears to have already begun. While some sources indicate the companies are postured for cooperation, they also indicate concerns about the governments' ability to work together. One source notes German experts are concerned the United States is not really willing to cooperate in the spirit of partnership and is interested only in selling black boxes. The National Institute for Public Policy study of European impressions of MEADS is replete with indications of European mistrust of U.S. government and industry, work-share arrangements, and U.S. technical requirements the Europeans do not want but will be asked to finance, etc.

One Production Line or Two?

Finally, the issue of production and final assembly lines has been only partially addressed. Apparently, the partners envision that there will be single sources for the various components, but that it is possible that there may be more than one final assembly and integration line. One interviewee noted that this will not completely obviate economies of scale to be achieved, as the greatest costs are in producing components in duplicative facilities. It remains unclear, however, whether or not the United States and Europe will want to produce critical components, such as seekers and guidance sections, domestically for national security reasons. In addition, decisions about how to handle third party transfers and sales of hardware have been left for future negotiations. For now, all foreground data transfers and uses for non-MEADS programs are subject to unanimous consent by the partners.

The Partners Currently Plan to Have A Consortium—Not A Prime Contractor

Defense officials indicate there is currently no plan to have a prime contractor, and that the companies will form a consortium, as MDTT, Inc., did for the MLRS/TGW. One source indicated that the governments support the consortium approach to maintain fairness among the partners. The sources did not indicate how they would overcome the problems caused by the lack of a prime contractor experienced in the MLRS/TGW.

If the MLRS/TGW program experience is a good teacher, the MEADS partners will change course and assign a prime contractor. If not, at the very least, they could establish a "lead" company in the consortium. The "lead" company would be the source of authority, responsibility, and accountability for the contractors' work. The lead company would also track progress, determine risk areas, and perform other management functions. In any case, the governments, companies, and—most of all—the program would be well-served to set up the consortium in a manner that permits equitable partnership, but ensures contractor accountability, responsibility, and leadership.

WILL THE PROGRAM HAVE A FULLY-STAFFED, FULL-FLEDGED INTERNATIONAL PROJECT OFFICE?

The MEADS will be managed by the NATO MEADS Management Agency, an international program office chartered by NATO. The agency will be located in Huntsville, AL. Current planning, reflected in Figure 3, is that there will be a multinational Program Executive Office-level Steering Committee. The U.S. Missile Defense Program Executive Office (flag officer) and its European counterparts will be members of the Steering Committee. This Committee will have authority over the NATO MEADS Management Agency. The General Manager position of this agency will rotate among European representatives throughout the entire MEADS program. Germany will provide the General Manager for the project definition–validation phase. Throughout all phases of the program, the United States will provide the permanent Deputy General Manager. In view of the 50 percent U.S. funding share, this was apparently a U.S. compromise arrangement arrived at in the negotiations.

The MLRS/TGW experience demonstrated the importance of having a truly international project office, with principals who have deciison making authority from

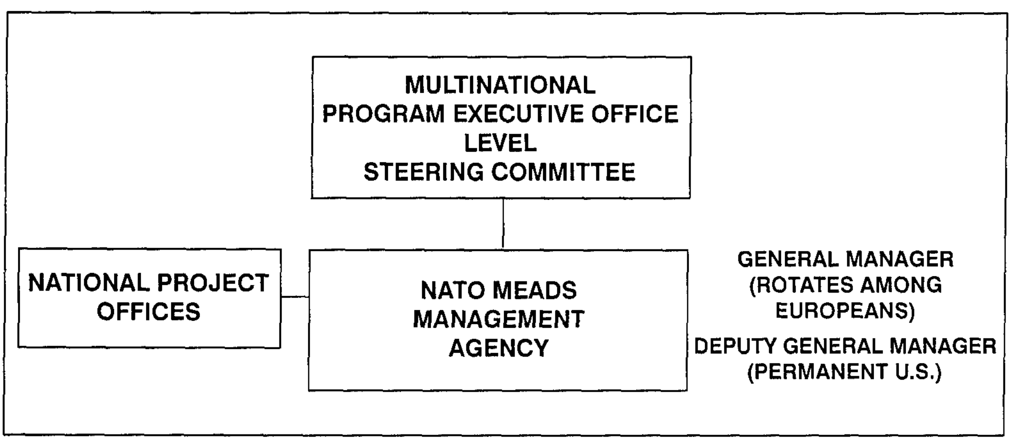

Figure 3. Planned MEADS Project Management Organization

all quarters living together to make a successful program. It remains unclear how quickly and how fully the NATO MEADS agency will be staffed, and with what authority its personnel will manage and oversee the program. The United States will continue to have a small (10-person) national project office, located in Huntsville. Will the Europeans maintain their national program offices, and retain all authority in their national capitals for decision making on tradeoffs, etc., that will inevitably arise?

How Will Decision Making Be Done?

Interviewees were uncertain about how decision making would be done in the program, both on the parts of the companies and the governments. They speculated, however, that a consensual approach was likely. One interviewee stated that the program would be managed and decision making would be on a "50:50 basis" in a true equitable partnership between the United States and the European allies. However, another noted that European block voting was already occurring on many issues during the negotiations, with Germany playing the swing vote in some issues with the United States.

A Comparative Snapshot

As shown in Figure 4, in some key program areas, the MEADS partners are following a path that is similar to the MLRS/TGW program. Having four governments and—even more complicated—six companies involved in the program will likely be problematic and costly. Through unusual teaming arrangements, MEADS

PROGRAM CHARACTERISTICS	MLRS/TGW	MEADS
Number of Countries/Companies	Four/Four	Four/Six
Mix of Countries	U.S., FR, GE, U.K.	U.S, FR, GE, IT
Percentage Cost Shares	40:20:20:20	50:20:20:10
Agreement on Threat Details	Not Fully	Not Yet
Contractor Selection	Winning Multinational Team with Some Weak Players	U.S. Companies Compete; Same Strong European Companies Win
Prime Contractor or Consortium	Consortium	Consortium
Work Share Based on Cost Share	Yes-to Second Tier	Yes-to Second Tier
Work Share Based on Company Strengths	Not Adequately	Unknown
Fully Staffed, Full-Fledged Int. Prog. Office	No	Unknown
Governments' Decision Making	Consensus; Single Vote Veto	Possibly Consensus
Companies' Decision Making	Consensus-Governments Involved	Unknown

Figure 4.
Comparison of Program Characteristics in MLRS/TGW and MEADS

partners have avoided the possibility of having weak companies participating in the program. However, having six companies operating in a consortium could lead to similar difficulties encountered in the MLRS/TGW program if leadership and accountability are not established. Moreover, some observers believe the MEADS program is already doomed to failure because the partners clearly do not agree on key elements of the requirements. However, if a prime contractor, lead company or similar approach is taken, and if the countries can harmonize their requirements or even agree on a formula for fencing off development and funding some of the requirements that are beyond France and Italy's interests, MEADS has a chance for success.

The MEADS partners are still in the early stages of establishing a cooperative program and can possibly benefit from the MLRS/TGW program experience. Front-end "damage limitation" can be applied in the areas in which decisions have not yet been made: determining technical work shares; staffing and decision making power in the international program office; and determining the approach to decision making both among the governments and the companies involved. *If the program fails, damage to the political relationships will likely be serious—it is in all the partner nations' interests to do what makes sense for the program.*

Conclusions

The MEADS partners can avoid some major pitfalls encountered in the MLRS/TGW experience if they:

- either get full agreement on a detailed set of requirements up front or fence off development and funding (and associated work shares) of requirements on which agreement cannot be reached;

- establish a prime contractor or a lead company/manager for the consortium;

- ensure technical work shares are equitably based on national cost shares and the companies' technological strengths, experience, and comparative advantages;

- quickly establish a fully-staffed, full-fledged international program office vested with national program office-level decision making power and authority; and

- avoid consensus decision making in which negative behaviors, such as single-vote veto, are available and can stop the program—adopt another, more positive team-oriented approach.

The former United States,United Kingdom, French, and German MLRS/TGW program officials and the current United States, French, German, and Italian MEADS program officials should hold a joint conference to more fully explore the problems encountered in the MLRS/TGW program, their causes, and alternative approaches to better ensure success for MEADS.

SPECIFICATION, HARMONIZATION, AND LINKAGE OF TEST PARAMETERS

Edward D. Jones

This article addresses how to best specify "what to test" parameters. It will also clarify the latest DoD 5000 series guidance as approved by the Secretary of Defense on 9 March 1996 on the establishment and maintenance of parameter linkage and harmonization among the key acquisition documents.

While the newly revised Department of Defense (DoD) 5000 series does make significant progress implementing acquisition reform, confusion will likely continue to exist in the test and evaluation arena as to how to best specify test parameters for an acquisition program (Figure 1).

A proliferation of "what to test" terminology remains among the various parts of the DoD 5000 series. A formal glossary that will perhaps define these terms is still being compiled. On pages 149–151 is a partial listing of "what to test" terminology used in this article. For purposes of brevity, acronyms may not be defined except in this terminology list. Braces and brackets indicate an acquisition document where the term is used.

"WHAT TO TEST"

Some of the "what to test" terms may refer to the same required capabilities and associated thresholds and objectives. Often, they do not. Inherent relationships or linkages are not specified for most of these terms. Figure 2 summarizes the DoD 5000 series mandated sources for the most important "what to test" parameters.

The proper usage of "what to test" terms in reports and in discussions with oversight agencies can be important. Some of the terms have their origin in Title 10 law. For example, effectiveness and suitability are addressed in legislation that mandates how we will conduct dedicated initial operational test and evaluation. The test manager and program manager must

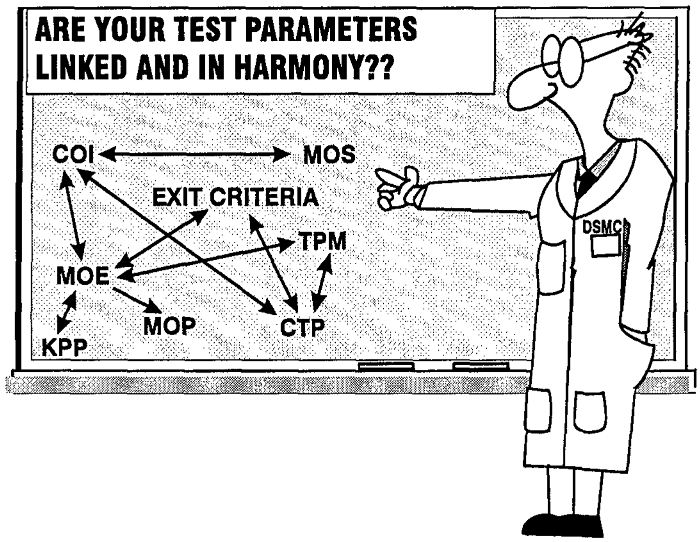

Figure 1.

take care when discussing what is actually being tested or evaluated. For example, assume a test for an ACAT ID acquisition program indicates that a threshold is not achieved for a TPM that is also a specified exit criteria.

Who has oversight for these test parameters? The contractor and government technical managers have oversight over TPMs. Unless the TPM is also designated as a critical technical parameter, it will not be listed in the TEMP and will normally not be subjected to Office of the Secretary of Defense (OSD) oversight at the overarching Integrated Product Team (IPT) level. However, all exit criteria by definition are under the direct oversight of the milestone decision authority (MDA). This means that failure to meet the threshold for an exit criteria could prevent the acquisition from proceeding into the next acquisition phase. This could be an emotional event! Compare this with failing to meet a threshold of TPM that is not a CTP or not specified to be an exit criteria. The contractor and government technical manager would take appropriate actions to solve the problem under the oversight of the program manger and the appropriate working level IPT. This article will recommend a method to specify test parameters that simplifies the "what to test" terminology.

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"What To Test" Terminology

Compatibility, Interoperability, and Integration (CII) Issues. {Appendix III, DoD REGULATION 5000.2-R} Defined to be critical operational issues that address compatibility, interoperability or integration issues. [Test and Evaluation Master Plan or TEMP]

Critical Operational Issue (COI). {Appendix III, DoD REGULATION 5000.2-R} A question that must be answered in order to properly evaluate operational effectiveness and operational suitability for a system. [TEMP]

Critical Operational Effectiveness and Suitability Parameters and Constraints. {Appendix III, DoD REGULATION 5000.2-R} Parameters and constraints as specified in the ORD that address manpower, personnel, training, software, computer resources, transportation (lift), compatibility, interoperability, and integration, etc. These parameters and constraints are included in the listing of measures of effectiveness and suitability in Part I of the TEMP. [TEMP, ORD]

Critical Technical Parameter (CTP). {Appendix III, DoD REGULATION 5000.2-R} Not defined. They are to be derived from the ORD, critical system characteristics, and technical performance measurements and should include the parameters in the acquisition program baseline. [TEMP]

Exit Criteria. {Paragraph 3.2.3, DoD REGULATION 5000.2-R} Exit criteria are some level of demonstrated performance (e.g., a level of engine thrust), the accomplishment of some process at some level of efficiency (e.g., manufacturing yield) or successful accomplishment of some event (e.g., first flight), or some other criterion (e.g., establishment of a training program or inclusion of a particular clause in the follow-on contract) that indicates that aspect of the program is progressing satisfactorily. [ADM]

Indicators. {Paragraph 3.4.3, DoD REGULATION 5000.2-R} One or more measurements that provide insight when compared with test-established thresholds. [Not mandated for usage in any key acquisition document; however, frequently used in test reports and program assessments.]

Key Performance Parameter (KPP). {Paragraph 2.3, DoD REGULATION 5000.2-R} A capability or characteristic that is so significant that failure to meet the threshold can be cause for the concept of system selection to be reevaluated or the program to be reassessed or terminated. [ORD, TEMP, Aquisition Program Baseline or APB]

Measures. {Used through out DoD 5000 series} Not defined. As defined in IEEE 1278.3, a qualitative or quantitative attribute used to ascertain or appraise by comparing to a standard. [TEMP, Analysis of Alternatives]

Measures of Effectiveness and Suitability (MOEs/MOSs). {Appendix III, DoD REGULATION 5000.2-R and in other parts} The following definition is inferred from a discussion of measures of effectiveness and suitability in Appendix III. The operational performance (effectiveness and suitability) parameters that specify capabilities, characteristics, and constraints as identified in the ORD. Each measure of effectiveness and suitability is to have a threshold and an objective. [TEMP, Analysis of Alternatives, ORD]

"What To Test" Terminology (continued)

Measure of Performance (MOP). {Paragraph 3.4.1; Appendix III, DoD REGULATION 5000.2-R} Not defined. A commonly accepted definition is: a measure, such as weight and speed, that relates to a measure of effectiveness such that the effect of a change in the measure of performance can be related to a change in the measure of effectiveness. {1992 OUSD (A&T) memorandum; subject: Implementation Guidelines for Relating Cost and Operational Effectiveness Analysis (COEA) Measure of Effectiveness to test and evaluation.} [TEMP, ORD Analysis of Alternatives]

Metrics. {Paragraph 4.3, DoD REGULATION 5000.2-R} Not defined. As defined in *Webster's Dictionary*, metrics is the extent or degree to which a product possesses and exhibits a quality, or property, or an attribute. This term is more commonly used when addressing software testing and evaluation. [TEMP]

Minimum Acceptable Requirements. {Paragraph 2.3, DoD REGULATION 5000.2-R} While not specifically defined, it can be logically inferred that minimum acceptable requirements are the minimum capabilities and characteristics that a system must possess in order to successfully accomplish all mission essential tasks. [ORD]

Objective. {Paragraph 2.3.2, DoD REGULATION 5000.2-R} The objective value is that *desired* by the user and which the PM is contracting for or otherwise attempting to obtain. The objective value could represent an operationally meaningful, time critical, and cost effective increment above the threshold for each program parameter. [TEMP, ORD, APB]

Operational Performance Parameters. {Appendix II, DoD REGULATION 5000.2-R} These are system level performance capabilities such as range, probability of kill, platform survivability, operational availability, etc. Each parameter should have an objective and threshold. [ORD]

Other Systems Characteristics. {Appendix II, DoD REGULATION 5000.2-R} A special category of characteristics that tend to be design, cost, and risk drivers. Examples include electronic counter-countermeasures (ECCM) and Wartime Reserve Modes (WARM) requirements and others as listed in Appendix II of DoD REGULATION 5000.2-R. [ORD]

Parameter. {DoD REGULATION 5000.2-R} This term is liberally used throughout the DoD 5000 series. It is not defined. As defined in the *American Heritage Dictionary*, a parameter is a variable or an arbitrary constant appearing in a mathematical expression, each value of which restricts or determines the specific form of the expression. Current usage in the DoD 5000 series and in other current literature used by the test community have broadened the definition to be equivalent to any test variable, whether formally part of a mathematical equation or not. Probability of hit is one example that does meet the technical definition of a parameter. [TEMP, ORD, APB]

Required Capabilities. {Used throughout DoD REGULATION 5000.2-R} Not defined. A commonly accepted definition is: system performance or characteristics that a system must possess in order to accomplish mission essential tasks. [ORD, TEMP, APB, Analysis of alternatives]

"What To Test" Terminology (continued)

Technical Performance Measurement (TPM). {Appendix III, DoD REGULATION 5000.2-R} Not defined. A common definition that is accepted in systems engineering follows: A product design assessment, which estimates through engineering analysis & tests, values of essential performance parameters of the current design of a work breakdown structure product element. [SEMP, contract]

Thresholds. {Paragraph 2.3.2, DoD REGULATION 5000.2-R} These are the minimum acceptable values which, in the user's judgment, are necessary to satisfy the need. If threshold values are not achieved, program performance is seriously degraded, the program may be too costly, or the program may no longer be timely. The spread between objective and threshold values shall be individually set for each program based on the characteristics of the program (e.g., maturity, risk, etc.). [ORD, TEMP, APB]

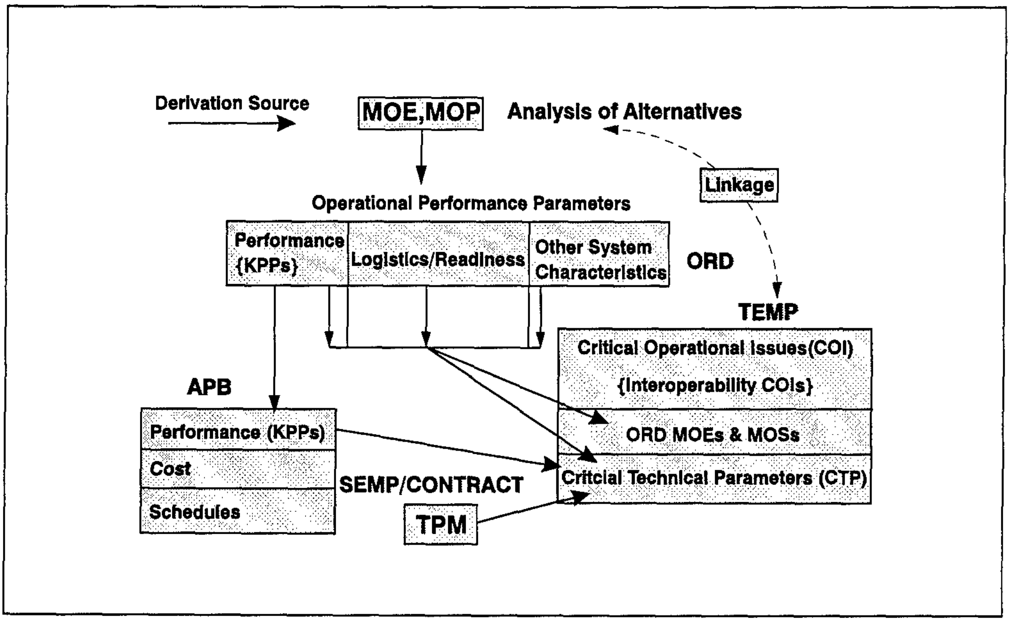


Figure 2. "What to Test" Parameter Sources

IMPLEMENTATION POLICY FOR PERFORMANCE PARAMETER SPECIFICATION

The TEMP lists the "what to test" parameters, outlines the strategy to conduct the testing, provides a summary of required test resources, and assigns responsibilities. *Note that the tester limits the "what to test" terminology to: measures of effectiveness, measures of suitability, measures of performance, critical technical parameters, critical operational issues, critical system characteristics and compatibility, inter-operability, and integration (CII) issues.* Terms such as software metrics, operational performance parameters, system constraints, minimum required capability and required capabilities are incorporated into the TEMP as one of the preceding "what to test" parameters, measures or issues! How do all the "what to test" parameters, measures, and issues that are commonly used by the tester tie together? Figure 3 illustrates the relationships between the "what to test" parameters during operational testing.

A critical operational issue (COI) addresses a key operational effectiveness or operational suitability issue that must be examined in operational test and evaluation to determine the system's capability to perform its mission. The COI is stated as a question and should address top system level mission essential tasks. MOEs provide (quantitative whenever practical) criteria that can be used to judge whether a system can effectively provide the required capabilities as stated in the ORD. Each MOE should provide information that is to be used to answer one or more effectiveness COIs. When a COI addresses suitability, the measure of effectiveness is replaced by the MOS. The MOP is a (quantitative when practical) criteria for a lower level of performance that is used to support the determination

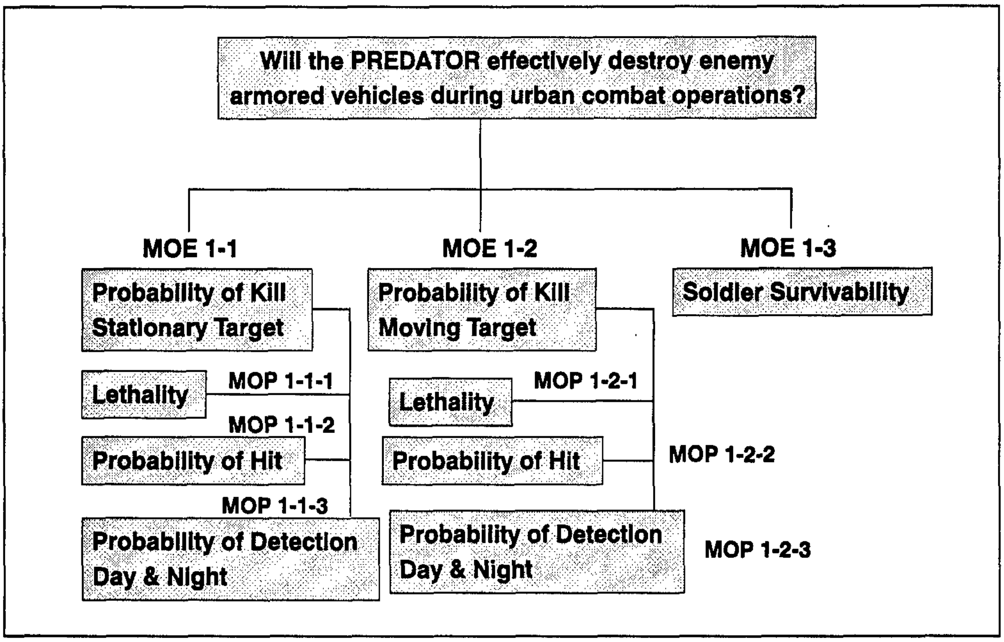


Figure 3. COI 1 {Effectiveness COI}

or assessment of one or more MOEs or MOSs. MOEs, MOSs, and MOPs are normally extracted directly from the ORD. In some cases, they must be derived from the ORD. On an exceptional basis, MOEs, MOSs, and MOPs can be recommended for testing by the Director of Operational Test and Evaluation (DOT&E) or by the appropriate component Operational Test Agency (OTA). This might occur when the OTA or DOT&E determine that the required capabilities and characteristics are not adequate for operational testing. MOEs, MOSs, and MOPs that are not extracted or derived from the ORD must be approved through the IPT process prior to being used for determination of effectiveness and suitability in an independent evaluation report such as the beyond low rate initial production report. The user will establish thresholds and objectives for any DOT&E or OTA recommended MOEs, MOSs, and MOPs.

COIs and operational performance parameters are most appropriately tested in an operational environment. An operational environment is the same or closely approximated environment that the system will be used in when issued to the user. Testing in a controlled environment that may significantly deviate from operational conditions or testing that is limited to a specific set of operational conditions is called developmental testing. Another "what to test" parameter listed in the TEMP is CTP. While MOEs and MOSs are specified to support the determination of effectiveness and suitability in an operational environment, the CTP is specified to measure progress in the hardware and software development to support the final product to be used in a fully operational environment. Developmental testing is normally the more appropriate type of testing for CTPs. DoD guidance is that the CTP may be derived from the ORD and critical system characteristics or chosen from the list of technical performance measurements as specified in the SEMP or extracted directly from the contract. System level TPMs that measure performance essential to accomplishment of mission essential tasks should be specified to be CTPs. A possible exception to this guideline is an extremely high risk component level TPM that significantly impacts one or more system level TPMs.

In the past, specification of CTPs versus minimum acceptable operational performance parameters (MAOPRs) has been problematic. For many programs, the CTP and MAOPR lists duplicated each other. The problem arises because the ORD is an approved source for both the MAOPR and the CTP. This issue remains in the revised DoD 5000 series. The MAOPR has been replaced with MOEs and MOSs. When should MOEs and MOSs also be CTPs? This article recommends an approach to CTP specification that will minimize duplication of CTPs and operational performance parameters (MOEs, MOS, MOPs) and, more important, clearly establish a key difference between operational performance parameters and CTPs.

This process is to simply limit the specification of CTPs to performance that is contractually specified. While this recommendation is not specifically supported by guidance in the DoD 5000 series, it is well within the guidance for parameter specification. For most acquisition programs, specified performance in a contract is best tested in a controlled environment during developmental testing. TPMs are by definition contractually specified and are always a valid source for CTPs. When operational performance parameters are specified in the contract, then they should normally be specified as CTPs. This recommendation will minimize duplication between operational performance parameters and CTPs. The specification process is based on the premise that operational performance parameters are best tested during operational testing while CTPs and TPMs are more appropriately tested during developmental testing. This process recognizes that some duplication will occur between CTPs and operational performance parameters and does not restrict the testing of each type of test parameter in either an operational, developmental, or hybrid mode of testing.

Now let us address the concepts of parameter linkage and harmony. The concept of parameter linkage and harmonization was first introduced in a March 1992 memorandum that was signed by the Under Secretary of Defense for Acquisition, the Assistant Secretary of Defense (Program Analysis and Evaluation), and the Director, Operational Test and Evaluation. This memorandum mandated that the TEMP should document how measures of effectiveness and measures of performance from the COEA will be addressed in testing and evaluation. In the COEA, measures of effectiveness were to be defined to measure operational capabilities in terms of engagement or battle outcomes for weapon systems. Measures of performance such as speed and weight were to be specified to relate to the MOE such that the effect of a change in the MOP can be related to a change in the MOE. It further mandated that the MOEs, MOPs, and criteria in the ORD, the COEA, the TEMP, and the APB should be consistent. These mandates were incorporated into Part III of the revised DoDI 5000.2 as quoted below:

> Linkage shall exist among the various MOEs and MOPs used in the analysis of alternatives or ORD, and test and evaluation; in particular, the MOEs, MOPs, and criteria in the ORD, the analysis of alternatives, the TEMP and the APB shall be consistent.

and

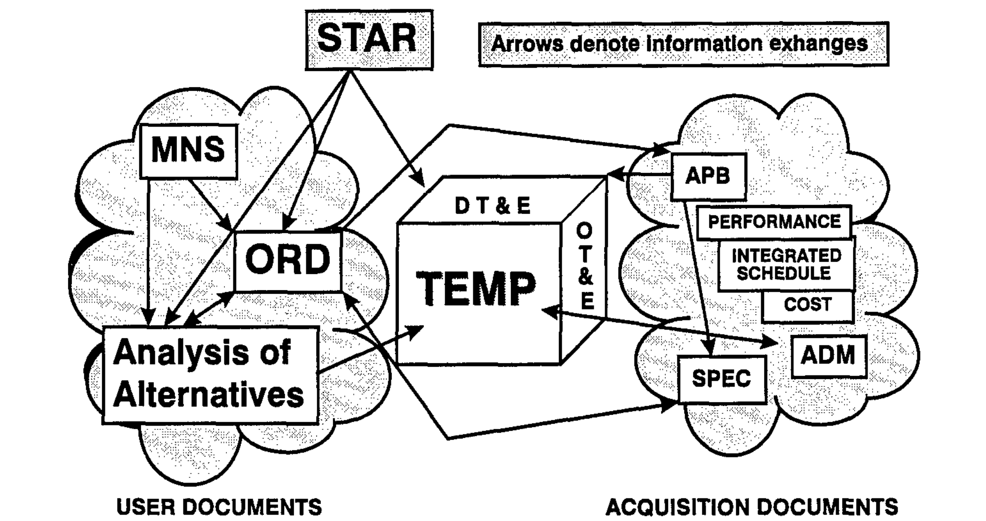
> Both developmental and operational testers shall be involved early to ensure that the test program for the most promising alternative can support the acquisition strategy and to ensure the harmonization of objectives, thresholds, and measures of effectiveness (MOEs) in the ORD and TEMP.

In the past, linkage was described as the process of associating (or linking) measures of effectiveness and measures of performance that were used as inputs in models and in analytic studies with actual test data and evaluated results that were based on actual test data. The purpose of this association was to ensure that realistic inputs were used in models and analytic studies. Harmonization was the process of ensuring consistency among the all the various measures and parameters to include associated thresholds and objectives. The translation of past guidance into the new DoD 5000 series has lost some of the precision associated with defining the linkage and harmonization process. Harmonization and linkage have adopted the same meaning, for practical purposes. That meaning is consistency. This consistency has three key ingredients:

- agreement on thresholds and objectives for the same measures and parameters,
- compatibility of measures and parameters, and
- realistic (consistent with test data) inputs into studies and models.

The concept of harmonization and linkage should be considered to mean the process of establishing and maintaining consistency among all the measures, parameters, and inputs to models and analytic studies. This consistency must extend to all the key acquisition documents (Figure 4).

Harmonization and linkage are most easily discussed practical examples; three follow. First, during an analysis of alternatives, assume that the threshold speed (a measure of performance) for an armored vehicle was established to be 80 km/h on improved roads. This threshold speed might be a significant input into the models and studies that recommended that tank A be the preferred alternative. Then assume that during developmental testing of a prototype tank A, it is discovered that this type of tank will not exceed 73 km/h on improved roads. It is also assumed that the engineering change proposals to increase the speed to 80 km/h is cost and schedule prohibitive. For this example, the concept of linkage and harmonization requires that actual test data for tank A on speed on improved roads be compared with inputs that were used in the models and studies that were used in the analysis of alternatives. Where necessary, previous



NOTE: MNS-Mission Need Statement; STAR-System Threat Assessment Report; SPEC-Specifications.

Figure 4. Parameter Consistency (Harmonization And Linkage)

inputs (measures of effectiveness and performance, system constraints, etc.) must be changed to reflect the more realistic inputs that are based on actual test data. For our example, we would have to establish whether the lower threshold speed of 73 km/h versus the earlier threshold of 80 km/h has a significant impact on the selection of the preferred alternative.

For a second example, assume the threshold for mean time between failure (MTBF) for a radio system to be 1250 h. The MTBF threshold would be listed in the TEMP, ORD and possibly in other key acquisition documents such as the APB. Assume the mean time to repair (MTTR) to be specified as 30 min at all levels of maintenance. In the analysis of alternatives, assume the system to have been required to have not more than 45 min of not available time for repairs on an annual basis. In the ORD or other user document, assume the system to have the requirement to be placed into operation for 2500 h on an annual basis. Now, the question to answer is: "Are these required capabilities and associated parameters in harmony (consistent)?" In this case, the required performance parameters are not in harmony. Simple math will reveal a discrepancy. During one year, the system should fail on average twice. Two times 30 min indicates that, on average, 60 min of downtime should be expected for this system. This conclusion indicates that the system should be expected to have more than 45 min of not available time on an annual basis. The "what to test" parameters among the TEMP, ORD, and analysis of alternatives are not consistent (harmonized). This problem can be fixed by decreasing the mean time between failure or by increasing the threshold for the not available time from repairs. The preceding example illustrates the compatibility aspect of consistency.

The final example illustrates the simplest aspect of consistency. That is simple agreement of thresholds and objectives for the same operational performance parameter or other "what to test" parameter. Assume that the TEMP lists a MOP that specifies the threshold for the probability of hit for a shoulder-launched missile to be 50% for stationary targets at 600 m. In the APB, assume the threshold for probability of hit to be 60% for the same conditions. To establish consistency, the probability of hit thresholds in the TEMP and APB must be the same for stationary targets at 600 m.

Now that we have discussed the "what to test" terminology and the concepts of linkage and harmonization, it is how time to establish an orderly and efficient process to effectively specify "what to test" parameters and to establish consistency (harmony and linkage) among measures, parameters, and inputs for models and analytic studies (Figure 5).

Test Parameter Selection, Linkage, and Harmonization

Step one. Establish a working-level IPT (analysis of alternatives/requirements/ what to test) that:

- specifies the required capabilities and operational performance parameters with associated thresholds and objectives in the initial ORD and the preliminary TEMP,
- inputs the required capabilities and associated operational performance parameters for each alternative considered in an analysis of alternatives,
- recommends performance parameters to be used in the draft APB,

STEP ONE:	ESTABLISH IPT.
STEP TWO:	DRAFT ORD.
STEP THREE:	SPECIFY COI AND CII.
STEP FOUR:	SPECIFY MOEs AND MOSs
STEP FIVE:	INPUT TO APB.
STEP SIX:	SPECIFY CTPs.
STEP SEVEN:	PREPARE PARAMETER DENDRITIC.
STEP EIGHT:	PREPARE CONSISTENCY MATRIX.

Figure 5. Eight-Step Process to Specify "What to Test" Parameters

- specifies the CTPs for the draft TEMP, and
- establishes and maintains consistency (linkage and harmonization) for all "what to test" parameters and criteria among all key acquisition documents. (APB, TEMP, Analysis of Alternatives, ORD, SEMP [if applicable]).

IPT membership should include representatives from the (1) user, (2) material developer, (3) operational tester , (4) developmental tester, (5) agency tasked to conduct analysis of alternatives, (6) logistics support agency, and others as appropriate. This IPT could be assigned the task of actually conducting the analysis of alternatives or be placed in support of another IPT that will perform the analysis of alternatives. In theory (in practice all the key acquisition documents are often prepared simultaneously), the analysis of alternatives is normally the first document to be drafted. The operational performance parameters that are used in the analysis of alternatives should not be system specific but should be applicable for all alternatives. The tester has the important role in this process of providing input as to how to properly state required capabilities in terms that can be tested. The user, as a member of the IPT, should take the lead in preparing a draft ORD with broadly defined system characteristics for each alternative under consideration. These draft ORDs will greatly aide in the analysis by providing a basis for numerical inputs for MOEs, MOSs, and MOPs that are used in the analysis. Step one has the following goals:

- Identify the performance and cost advantages and disadvantages between proposed systems over the existing system and/or a modified system.
- Broadly define the system characteristics needed in the new system.
- Select the preferred alternative to carry into Phase I of the acquisition cycle.

Step two. The IPT, with the user taking the lead, should then formalize the draft ORD (see step one) for the preferred alternative. In paragraph four of the ORD, list the required capabilities as operational performance parameters. The format for the ORD is prescribed in Appendix II of DoD REGULATION 5000.2-R. Results from the analysis of alternatives should be used to better define those system characteristics that are important in ensuring that the system meets the user's needs. The operational performance parameters in paragraph four of the ORD should be stated in a manner that facilitates their translation into MOEs, MOSs, and MOPs for listing in the TEMP. Each operational performance parameter should be readily identifiable and have a clearly stated threshold and objective. Examples of good and bad operational performance parameters follow:

Good: The KILLER must have a probability of kill for stationary targets that meets or exceeds 90% in the range band of 20– to 250 m during day operations in all types of weather and terrain. The desired probability of kill for this type of target is 95%.

Bad: The KILLER must have a probability of kill for moving targets that meets or exceeds that of the legacy system.

Comments: The good operational performance parameter clearly indicates that the test parameter is probability of kill. It clearly states the threshold and objective. It also provides an adequate amount of information to establish the environment. The bad example fails to clearly state the thresholds, objectives, and environmental conditions.

A preliminary choice of KPPs should be made at this time. They will be formally approved at component level and by the JROC.

Step three. Specify the COIs and the CIIs. As part of the IPT process, the user and the operational tester should assume the lead in the specification of the COIs and CIIs. The COIs should address the top system level mission essential tasks. A good source for the identification of COIs are paragraph one and the introductory statements for paragraph four in the ORD. For example, the ORD states that a helicopter will conduct armed and unarmed reconnaissance and security operations in combat. An appropriate COI that addressed this mission essential task might be: "Can helicopter A conduct armed and unarmed reconnaissance and security operations in combat?" COIs are questions that when answered support a determination of system effectiveness and suitability. The number of COIs to adequately address effectiveness and suitability normally range from 3 to 10. The absolute minimum is 2, one for effectiveness and one for suitability.

The determining factor as to how many COIs are needed is the number of mission essential tasks. Carefully specified COIs have the potential to address more than one mission essential tasks. Each COI requires a sufficient number of MOEs or MOSs to adequately determine an answer. An excessive number of COIs tends to increase the total number of test data elements that must be collected during operational testing and should be avoided whenever possible. The CII is a special type of COI that addresses compatibility, interoperability, or integration issues. A good source for the specification of CIIs is the other system characteristics listed in paragraphs 5f and 5h in the ORD. It is possible to specify one COI that adequately addresses all the compatibility, interoperability, and integration issues. For example, "Is the KILLER compatible and effectively integrated with other systems on the battlefield? Note that this is a standalone system and has no interoperability issues."

Step four. As identified in the ORD, specify system specific MOEs and MOSs and supporting MOPs as required. List the thresholds and objectives for these operational performance parameters in matrix format (recommend by the author but not mandated by DoD REGULATION 5000.2-R) in Part I of the TEMP. The ORD also suggests that those operational performance parameters that support the determination of other parameters be designated to be MOPs. A numbering scheme should be used to reflect which parameters are MOEs and MOSs and which parameters are MOPs. For example, MOP 1-2-3 indicates that this operational performance parameter is MOP 3 and that it supports the determination of MOE 2 or MOS 2 which supports COI 1. If COI 1 is an effectiveness COI then MOE 2 is appropriate.

COI	MOE/MOST/MOP/CTP: (Parameter): Threshold/Objective	Analysis of Alternatives: Threshold/Objective	APB Parameter: Threshold/Objective
COI 1: Kill Enemy Armor?	MOE 1-1 (Probability of Kill: .9/.95	Probabilty of Kill: .9/.95	Probability of Kill: .9/.95
	MOE 1-2 (Survivability): Yes or No	Survivability	
	MOP 1-1-1 (Probability of Hit—Moving): .5/.8	Probability of Hit—Moving: .5/.8	Probability of Hit—Moving: .5/.8
	MOP 1-1-2 (Probability of Hit—Stationary): .8/.9	Probability of Hit—Stationary: .8/.9	Probability of Hit—Stationary: .8/.9
	MOP 1-2-1 (Soft Launch): Yes or No	Soft-Launch Capability	Soft Launch Capability
	MOE 1-3/CTP 3 (Weight): 20 lbs/16 lbs	Weight: 20 lbs/16 lbs	Weight: 20 lbs/16lbs
COI 2-Supportable In Combat?	MOS 2-1 (Reliability) .9/.9	Reliability: .9/.9	Reliability: .9/.9
	MOS 2-2 (Transportable): Yes or No	Transportable: Yes or No	
	MOS 2-3 (Maintenance Concept): No Maintenance Required	Maintenance Concept	
Etc.	Etc.	Etc.	Etc.

Figure 6. Consistency (Harmonization-Linkage) Matrix

Step five. If not the same IPT, this IPT should provide a recommended list of performance parameters to the IPT that is drafting the APB. Those parameters should be limited to those parameters designated as key performance parameters in the ORD. The MDA has the latitude to add other performance parameters to this list. Performance parameters that are cost drivers are candidates for inclusion as a performance parameter in the APB. The analysis of alternatives should be an excellent source document for the appropriate IPT to use to identify performance parameters that are cost drivers. For example, miles per gallon for the M1A2 tank is cost driver for life cycle costs for the tank.

Step six. Specify the CTPs. In the past CTPs and MAOPRs (now called operational performance parameters) were considered to be interchangeable. But CTPs should be considered to be distinctly different from operational performance parameters. Operational performance parameters are more appropriately tested in an operational (uncontrolled) environment; CTPs are more appropriately tested in a developmental (controlled) environment. As part of the IPT process, the material developer representatives supported by the contractor and the government technical test manager should take the lead in CTP specification. While the ORD is specifically stated to be a source for CTPs, they should be limited to system level performance that is specified in the contract. Technical performance measurements are normally used by the contractor and the government system engineers to manage the engineering development of a system. The most significant system level technical performance parameters are the best candidates for selection as CTPs. Not all system level TPMs should be designated to be CTPs—only those can be directly linked to supporting a mission-essential task from the ORD. For example, a system-level TPM might be miles per gallon under tightly controlled driving conditions. This TPM directly supports the achievement of a mission-essential task for tank mobility without refueling for some specified distance. Therefore this TPM is an appropriate CTP. Appendix III of DoD REGULATION 5000.2-R states that CTPs should include parameters from the APB. I recommend that this guidance be implemented as follows:

Those parameters in the APB that are already specified to be operational performance parameters (MOEs, MOSs, or MOPs) from the ORD need not be specified as CTPs unless those operational performance parameters are also contractually specified. Those APB parameters that are not operational performance parameters and are not contractually specified should be specified to be an operational performance parameter if the parameter is most appropriately tested in an operational environment or a CTP if more appropriately tested in a controlled environment. In either case, the specified CTP or operational performance parameter should be annotated to reflect that the source for the parameter is the APB.

Step seven. Prepare a "what to test" parameter dendritic that shows how all the test parameters are related to each other (Figure 7). This dendritic is useful in checking for consistency among the "what to test" parameters and is useful in test planning in determining what test data elements will be needed. When complete, all MOEs and MOSs must be linked to a COI. If not, specify a COI that addresses the top-level issue that the MOE or MOS addresses. All CTPs should be linked to a MOE, MOS, and in some cases directly to a COI. Note that the dendritic includes both CTPs and operational performance parameters. Those CTPs that are not operational performance parameters should be linked to COIs and MOEs, MOSs, and MOPs. This linkage is important in determining how technical performance affects required capabilities. During operational testing, the OTA has the latitude to treat a CTP that is not duplicated by an operational performance parameter in the same manner that operational performance parameters are treated. The primary differ-

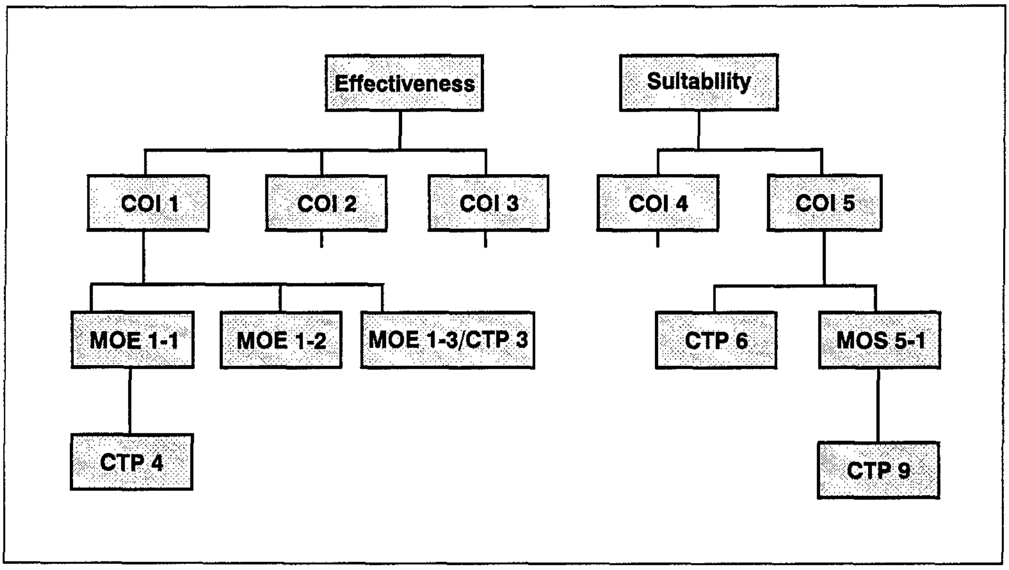


Figure 7. Test Parameter Dendritic

ence is that the environment that was controlled for testing CTPs is now uncontrolled. The OTA is not limited to previously specified thresholds for a CTP. During operational testing, the CTP is simply a criteria to be used in the evaluation and determination of MOEs, MOSs and MOPs.

Step eight. The final step in this process is to ensure that consistency (harmonization and linkage) is established between the "what to test" parameters among the key acquisition documents (TEMP, ORD, APB) and the measures criteria used in the analysis of alternatives.

CONCLUSION

This article has discussed the latest DOD 5000 series guidance on specifying "what to test" parameters, how to establish consistency (harmony and linkage), and has outlined an eight step process to implement this guidance.

This process is complicated by the complex terminology that varies within the various parts of the DoD 5000 series. A key simplification is to limit CTPs to contractually specified performance that is most appropriately tested during developmental testing. The operational performance parameters from the ORD are listed in the TEMP and are more appropriately tested in an operational environment. This type of specification process does not prohibit the test manager from testing some of the operational performance parameters during developmental testing or testing CTPs during testing that is primarily operational in nature. In fact, a wise program manager will ensure that this happens. However, this process does clearly recognize that operational performance parameters are designed for operational testing while critical technical parameters are designed for developmental testing.

IMPLEMENTING INTEGRATED PRODUCT DEVELOPMENT: A PROJECT MANAGER'S PERSPECTIVE

Richard W. Bregard and Taylor Chasteen

This is a first-hand account of an actual Integrated Product Team implementation experience from the project manager's perspective. Using the vision articulated by senior leaders in the Department of Defense and the Army, the manager tailored a practical approach to fit the development effort. Implementing an integrated product development (IPD) approach that can return significant benefits is a formidable task, over and above the serious technical and programmatic challenges facing the team. The authors discuss the historical and cultural reasons for the resistance to IPD they experienced. They explore the types of teams and implementation steps in terms of their value added to the end product. Finally, the authors express some concerns about the future of IPD and its role in changing the established organizational culture.

Officially chartered in 1979, the mission of the Office of the Project Manager for Tank Main Armament Systems is to manage the development of Abrams Tank lethality systems, including armaments and ammunitions systems. Over the past 17 years, the Project Office has been extremely successful at this mission. One current ammunitions program is the M829E3, 120mm Kinetic Energy Cartridge. The goal is to develop and produce the most lethal and accurate kinetic energy round the world has ever seen. This is proving to be the most technically challenging project this office has ever attempted. Moreover, the project must operate in an environment of shorter development cycles and very limited funding. To increase the chance for program success, the office determined initially that it must fundamentally change the way it manages development. While the more traditional management styles have been successful, they now appear too costly and time consuming to survive in the new era of military and product modernization.

A relatively new management model, Integrated Product Development (IPD), offers substantial benefits that would help overcome these challenges. Flatter organizations and more teaming are central tenets of the IPD philosophy. The Department of Defense (DoD) has tailored the IPD philosophy by instituting the Overarching Integrated Product Team (OIPT) to help solve problems and expedite the decision process at a higher level of defense acquisition management. Meanwhile, senior DoD and Army leadership charges the project manager (PM) with responsibility to foster the Integrated Product Team (IPT) at the working level.

IPD integrates all relevant skill sets early in a product's life cycle and pushes critical decision making authority down to the lowest possible level. Early integration of skill sets increases the probability that issues are raised and solved early in the life cycle. Streamlined decision making decreases development time, reduces personnel costs, and improves integration of the total product. However, correctly implementing the IPD philosophy can be difficult. In this case, it required a fundamental cultural change throughout government and private contractor organizations that had successfully managed 120mm tank cartridge development for decades. This paper describes our recent IPD implementation experience in the Office of the Project Manager, Tank Main Armament Systems.

CONTEXT

Project management in today's Army requires the PM to solicit and employ expertise from various government organizations and contractors. During the previous era of ammunition development, developmental government organizations became characterized as too hierarchical, with engineers and scientists working at the lower levels, engineering management above them, and business management on top. Generous project money helped support this management structure. Past funding levels also supported independent, and sometimes simultaneous, development programs having several contractors whose hierarchical management structures reflected those in the government organizations they were supporting.

Though top heavy and sometimes ponderous, 120mm tank munitions development was very successful. Problems were solved by focusing on the product and schedule at the expense of cost. Cost was not an independent variable. Successful programs and a tradition of adequate funding created a natural bureaucratic inertia in the organizations that develop tank munitions. When these efforts began, gov-

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ernment and contracting organizations were resisting significant process changes despite the funding pressures experienced over the last few years. Recently, changes in organizational thinking have taken place.

Contrasting IPD With Tradition

In the generic and more traditional project management model, the project office manages funding, development, product integration, transition from R&D to production, and fielding. However, due to limited staff, independent technical organizations such as design engineering, testing, and procurement often provide matrix support to the PM. Unfortunately, along with the technical expertise comes layered functional management. Decision making is slowed by time-consuming meetings, briefings, and staffing requirements.

Complicating matters further, each functional organization, working on its piece part, vies for resources provided by the project office. The competition is good, but at a micro level, the result is often over- and under-funding of the differing technical areas. Under-funded areas naturally cause project delay. Redesign, which is costly and generally reserved to solve integration problems, increases program time and money requirements. Thus, the decision making process is further aggravated by management "stovepipes" and inefficient communication.

On the private contractor side, businesses tend to closely mirror the organizational structure and culture of their counterpart government customers. Again, generous project money supported this approach. Many of the same problems associated with powerful functional organizations and layered management also exist with the contractors. Some private companies have embraced acquisition streamlining and IPD on their own. Others resist change and are waiting for their government customers to take the lead. Clearly, there are significant efficiencies yet to be realized from both the government and contractors.

In contrast to the more traditional approach, IPD is the integration of all needed skills (program management, technical development, producibility, etc.) early in the product's life cycle. In the language of IPD, the team, the (IPT) implements the IPD philosophy. The core IPT has overall responsibility for managing both the programmatic and technical decisions and looks for means to integrate the product (i.e., tries to understand the mutual impacts of the product's various piece parts) early in the life cycle. The team leader and members are empowered by their respective organizations. Indeed, most decisions can be made within the context of the team. Consequently, many of the briefings, meetings, and staffing requirements are reduced if not eliminated.

Moreover, with the team making resource allocation decisions in one "stovepipe," thereby subordinating functional interests to the goals of the team, program management is optimized to avoid schedule and overall product performance impacts. Equally important is the fact that more informed decisions can be made on the most important cost drivers early, when most of the program cost is determined. Agreed-upon team goals and metrics create pressure to manage within budget and schedule. Ultimately, rapid communication, team empowerment, integration of all relevant skill sets, and team synergy result in a shorter decision cycle and lower development costs.

IPD Implementation

Transition to IPD is made possible by a commitment to acquisition reform by senior leadership in DoD, DA, PEO, Armored Systems Modernization and the Army Materiel Command. Senior management support is critical to IPD due to organizational inertia and general resistance to change. Similarly, IPD is critical to acquisition reform in the sense that it allows us to do more with less, brings the acquisition community (public and private) closer together, both horizontally and vertically, and facilitates better, faster, more effective communications. Clearly the timing is right to shift to this new development philosophy.

Ideally, integrated product development teams form before development projects are transitioned to a project office. In actuality, this is rarely the case. When it was decided to manage the M829E3 program using the IPD approach, advanced development work had been ongoing for a couple of years. Fortunately, the office maintains a relatively seamless relationship with the organizations that provide most technical expertise, the Army Research Laboratories and the U.S. Army Armaments Research, Development and Engineering Center. This close working relationship mitigated the reality that the formal team structure was not in place as early as desired. Also, since the program is in the early technology demonstration phase, using an IPD approach will still have a significant beneficial impact.

What Type of Team Should Be Used?

There are many types of teams including integrated product development teams, concurrent engineering teams, integrated concept teams, and process action teams that may be chartered to deliver products, concepts, or processes. Teams are chartered for various lengths of time, perhaps to encompass an entire product life cycle or to address a specific process or task, and then disbanded. It is very important to understand how to differentiate types of teams, because of a tendency to paste the IPD label on "business as usual," and the concern that the wrong type of team would be established for the M829E3 development.

To address this organizational need for a better understanding of teams, this office conducted a serious review of the range of optional team structures and implementation strategies. Specifically studied were lessons learned and guides from the private sector, Department of Defense, Army Materiel Command, and the U.S. Air Force. Particularly interesting is the work of Steven Wheelwright and Kim Clark. In their book *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*, they define a spectrum of teams classified as lightweight, heavyweight, and autonomous. The spectrum is largely differentiated by the strength of the team leader and the amount of empowerment the team is given, starting from the least empowered lightweight to the most empowered autonomous team.

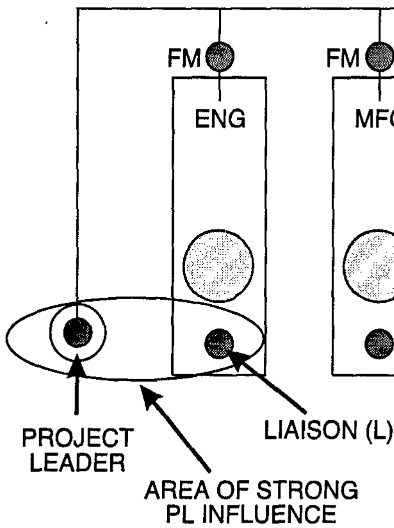

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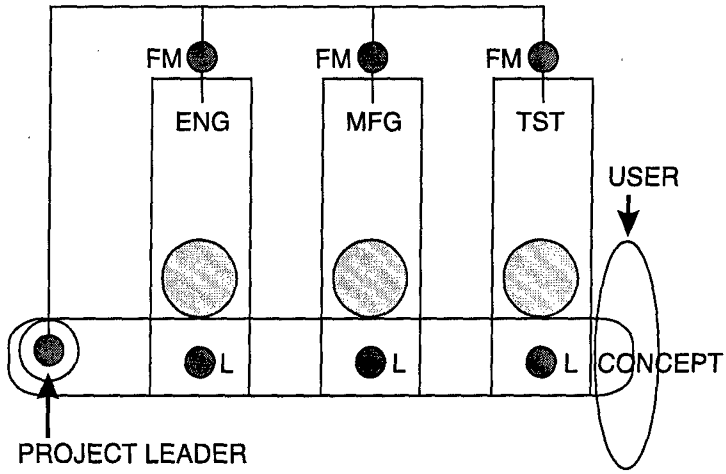
Figure 1. Lightweight Team Structure

The lightweight team structure, depicted in Figure 1, is distinguished by a team leader who is usually a middle or junior person in the parent organization. He is more of a coordinator than a leader. Additionally, the lightweight team leader does not control critical resources. Team members remain physically located with their functional organizations. Rather than focusing primarily on the work of the team, team members look to their functional organizations for daily support, guidance, and priorities. Responsibility for team member's evaluations, training, and support resides solely with the functional organization. The lightweight team is, in effect, a reflection of the way our products have traditionally been managed.

The heavyweight team structure, shown in Figure 2, has a *strong* team leader with collocated core team members. The leader is directly responsible to senior management for all the work done by the team. Core team members are collocated with the team leader. The team leader has a direct influence on the performance appraisals of team members and indirectly influences extended team members through his influence over the core team. The team is empowered to make decisions in a streamlined environment, eliminating the need to get functional management approval. The team has control over key resources, and the team leader has influence across organizations. While it is a significant departure from the traditional development model described earlier, the heavyweight structure occupies the middle part of the team spectrum.

Finally, the autonomous team structure, depicted in Figure 3, is distinguished by a strong team leader, little communication



- Heavyweight team leaders have experience, expertise, and organizational clout.
- They have primary influence on the core members of the team.
- Often the core members are physically collocated with the heavyweight leader.
- However, the longer term career development continues to rest with their functional managers.

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Figure 2. Heavyweight Team Structure

with upper management, and a great deal of empowerment. Sometimes referred to as a "tiger team," the autonomous team members are full time, dedicated, and collocated with the team leader. They have full control over resources, practices, and procedures. Likewise the team has full responsibility for success or failure of the project. This type of team is most appropriate for a new product development requiring an unusually rapid development cycle. Of course, with so much delegation of power, this type of team often makes senior management nervous.

In his book *Managing in a Time of Great Change*, Peter F. Drucker also discusses three types of teams. Drucker approaches the team issue from both a structural and humanistic perspective. He uses the analogy of a baseball team, a football team, and a tennis doubles team. In Drucker's view, baseball is much like an assembly line. The process is stable. Everyone has a job and if you mess up, usually there is no one who can help. Although aficionados may disagree, Drucker says, "[B]ase-ball players play on a team; they do not play as a team." In contrast, football is more flexible and fluid. There are usually opportunities to do more than

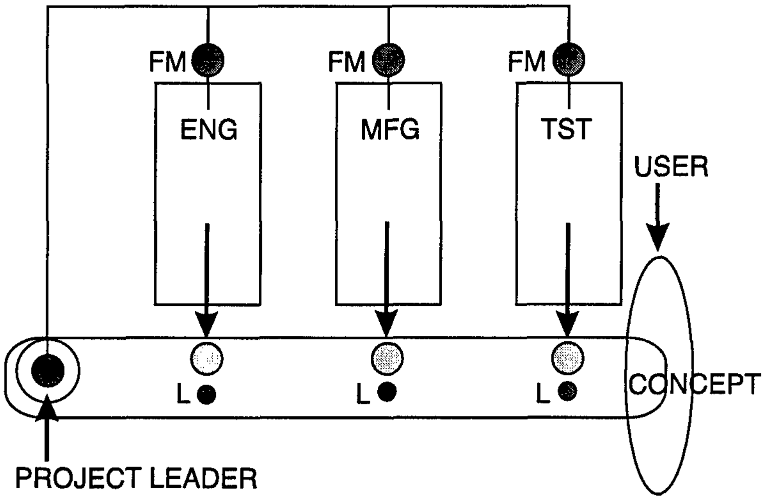

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Figure 3. Autonomous Team Structure

your specific assignment on a given play. Therefore, football players must play *as a team* to be successful. Finally, the tennis doubles team requires still more synergism than the previous two examples. Both players must be in total sync to win. In Drucker's example, the Japanese create this kind of synchronization by using design teams that incorporate the various relevant disciplines working in parallel. As in football and tennis doubles, each member must subordinate themselves to the team to be successful.

The lightweight team, with a weak team leader having little influence over team members and few incentives to create team synergy, did not seem to offer a credible chance to provide the real benefits this office wanted to achieve. Likewise, the autonomous team, with its considerable empowerment and associated high risk, was not appropriate for the M829E3 development. In extreme cases, such as war or serious immediate threat to our national security, the autonomous team may indeed be preferable. Instead, a composite of the heavyweight or football type team was chosen because it represented the greatest possibility for efficiency and synergism, given a long-term developmental program in its early stages.

Specifically, a robust heavyweight team could be tailored by incorporating all relevant disciplines for tank ammunition development and capable of managing the entire life cycle. Core team members could be collocated to the maximum extent, the team could be empowered to make decisions in a streamlined environment. Yet, the team's freedom would be bounded by the legitimate authority reserved by the project manager and codified in the team's documentation. The heavyweight team would be able to "push the envelope" in terms of faster communication and decisions, without going to extremes in terms of empowerment and associated risk. This type of team seemed to be a proper balance of risk and reward for a full-scale development program.

Implementation—Ex Post Facto

After the team was chosen, an implementation strategy was designed that offered the best chance for success. It was a very methodical approach consisting of four discrete steps in hopes it would help avoid major problems. In order, the implementation steps were readiness assessment, senior management training, facilitator training, and team launch.

The process of putting the team in place would take five months (six, counting the government furlough of November 1995). That seemed reasonable, since successfully negotiating the hurdles of change requires a great deal of brainstorming and thought. Namely, for the first time since the office's charter was enacted, it was empowering a heavyweight integrated development team to manage a program. This was in fact significantly changing the organizational culture of the tank ammunition business. Meanwhile, the office was managing a technically challenging effort, which was moving at a rapid pace, and was underfunded. The challenge was huge—so were the rewards.

Readiness Assessment

A readiness assessment was critical to IPD implementation. Its purpose was to assess the potential organizational and cultural barriers to the successful IPD effort. From top to bottom and across the organizations providing human resources to the team, relevant persons were asked to fill out a questionnaire concerning how ready the organization(s) were to accommodate IPD. The questionnaire addressed ten areas, including customer focus, senior management support, agility, etc. Respondents were asked if they thought team members understood customer requirements, whether there was sufficient senior management support, and if team members were committed to IPD. The responses to the questionnaires were used in follow-up interviews to amplify the responses. The data was compiled, organized, and quantified.

The value of the assessment was threefold. First, the large body of responses identified the problem areas more reliably. Second, anecdotal information was turned into quantifiable assessments that could readily be used to identify organizational barriers to IPD. Third, the assessment process was viewed as objective information gathering. This tended to take parochial politics out of the process to a great extent and provided a more solid foundation for the steps that followed.

To address the potential barriers identified in the readiness assessment, the office needed a vehicle in which to codify an organizational framework across several organizations. (These organizations included the Office of the Project Manager for Tank Main Armament Systems, Abrams Project Office, Army Research Laboratories and the U.S. Army Research Development and Engineering Center. The Ordnance Support Contractors, OLIN Corp and Alliant Techsystems were also involved on an *ad hoc* basis.) Hence, a Memorandum of Agreement (MOA) was drafted around the heavyweight team structure, incorporating solutions to the concerns identified by the readiness assessment. Importantly, the MOA included the extent and limitations of authority provided to the IPT. There were also specific mandates to the IPT, such as a requirement to develop process plans like communication, decision making, and administration. Finally, the MOA included clauses that would foster team development, addressing issues like collocation, performance appraisals, and team awards.

SENIOR LEADER TRAINING

Senior leadership training came next. Many IPT implementation plans eliminate this step. Typically, new worthy concepts gain favor and people assume that senior management has a thorough understanding of the concept and associated issues. That is a false assumption. Also, leadership must sometimes un-learn false notions derived from incomplete knowledge and years of managing the old way. Many times the results of not training senior management are lack of support, misapplication of concepts and failed efforts. This office set out to avoid this trap.

IPD senior management training was combined with a full discussion of the MOA in a two-day meeting. Dr. Jack Byrd of the Center for Entrepreneurial Studies and Development, Inc. (CESD, Inc.), a leader in the field of IPD, facilitated the meeting. Attendees included senior executives and upper management from the four major governmental organizations providing human resources to the M829E3 effort. Senior managers from the potential systems contractors were also included in the two-day meeting as ad hoc members and potential signatories to the MOA.

Senior leader training was very successful. Discussions of the M829E3 program and IPD philosophy led to a specific agreement to embrace IPD. Armed with a laptop computer, the meeting recorder made real-time changes to the MOA as discussions progressed. By the end of the second day, the leaders of the four major organizations signed the MOA. This event marked the end of the first phase of implementation and was a major step in generating cultural change. The significance of a signed MOA demonstrated the highest level of commitment of the organizations involved. Moreover, these leaders gave the IPT the freedom of action it would need to return real benefits.

FACILITATOR TRAINING

The facilitator of the senior management training is essential to achieving the stated goals for the meeting. Good facilitators plan a meeting. In conjunction with the team leader and subject matter experts, the facilitator lays out the agenda, goals, time limits, and ground rules ahead of the meeting. The facilitator then manages the dialogue using various facilitation techniques and focusing the group on the goals of the meeting. The facilitator gets everyone involved and promotes meeting ownership. Trained facilitators are key to maximizing the time spent in meetings.

Candidates for facilitator training were chosen for their personality, expertise, and mental agility. In addition to training members of the team, the office also trained facilitators who were not part of the team and who could be used as independent resources. Facilitator training was timed to coincide with team launch, thus allowing the trained facilitators to apply their newly acquired skills. This training approach incorporated current product and process issues facing the IPT. Hence, trainees accomplished real work instead of exercising with case studies and hypothetical examples. This approach was a constant theme throughout implementation.

Team Launch

The final phase of implementation was team launch. The purpose of this phase was to carry out the mandates embedded in the MOA. The launch was the most difficult, and some said the most critical, stage of IPD implementation. It is during the launch process that the reality of cultural change becomes apparent. As specifics are discussed and decisions made, the extent to which old lines of authority are being severed and new ways of operatingput into place becomes clear. The increased responsibility is felt by team members and the old hierarchical system reacts nervously.

To implement the launch, team members focused on process issues. Members developed team norms and decision making plans, along with a host of other process plans. Since this was a labor-intensive effort that required time and depth of consideration, the launch activities were split into two parts. First, a two-day session attended by the core team (about eight persons) was held to develop "strawman" plans. An interim period of three weeks passed to allow for discussion and thought before the 'strawmen' were presented to the whole team. Changes were made to the strawmen and the plans were placed into a team contract book. The contract book is a collection of governing documents for the team, such as the team leader's charter, MOA, and all the process plans developed through the launch process. The plans are considered draft; the team can always change them. On the last day of team launch, the team leader was presented with a written charter that delineated his responsibilities as the leader of the IPT. This event signified the end of the implementation process.

The implementation plan required a great deal of hard work that was accomplished without halting the technically challenging program. Big challenges lie ahead. The team is expected to return immediate benefit. For example, the Quality Functional Deployment (QFD) model with a common dictionary ensures that user requirements and trade off decisions are understood. The uncertainty risk reduction tool provides a formal process to manage risk over the life of the development. The decision making process compliments the empowerment given to the team in the MOA. As the team matures and goes through team development phases over time, it will develop confidence and operate more efficiently as team members and functional managers become comfortable within this new organizational framework. In due time, the team owes management an objective evaluation of its effectiveness. Team metrics and goals, developed during the launch process, will be evaluated and the real successes and disappointments weighed.

Issues And Conclusion

There are still many issues to be addressed with regard to Integrated Product Development. After years of creating large and powerful functional organizations, we must clarify the role of the functional organization and indeed the respective management structure. We have created career tracks for employees that use the hierarchical functional organization as the centerpiece of career aspirations. What is the logical career track for IPT members? How do we accommodate team members who have been collocated with a team for three years and return to their functional organization? These issues transcend any one organization. They go to the heart of the way we manage civilian personnel in the government and the future of IPD in this business.

IPD is still viewed as a serious threat by some in the public and private sectors. Failure to deal adequately with these issues could easily lead to pasting IPD labels on programs without making real changes in the way they are managed. The workforce is watching how team members are treated. We must address their needs and their career aspirations. Failure to do so will deliver a hard blow to IPD. Successfully addressing issues such as these will be the final blow to an outdated and costly way of doing business.

Cultural change takes years to accomplish. The momentum for IPD is strong now, but we must be vigilant to make it last. The automotive industry, for example, was traditionally very bureaucratic and slow to market_that is, until foreign competition brought incredible pressure on the players to make real changes to their organizational culture. Yet, some would argue that the automotive industry is still going through cultural change after 15+ years. We are not so different. Therefore, we must be prepared to accept the risks and continually push for this new management paradigm.

The real proof of IPD lies in the product we deliver to the soldiers. If IPD does not provide them with the best equipment available, in a timely and cost-effective manner, then we have not implemented it correctly. IPD is clearly the wave of the future in the private sector. There is a large body of evidence that supports this statement. Saturn develops new cars in 18 months. From first concept to flying production models, Boeing develops airliners in less than six years. We should be able to match this kind of performance in the defense acquisition system. IPD is our best opportunity to achieve this goal.

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BLINDING SPEED EQUALS COMPETITIVE ADVANTAGE

G. Dean Clubb

Texas Instruments Defense Systems & Electronics Group has actions underway to achieve a precipitous reduction in the time now required to design, develop, and manufacture products that meet customer needs. The customer's No. 1 priority is to receive a quality product at the lowest price. So why is Defense Systems and Electronics Group focusing on cycle time? One might ask, "How does TI's vision of reducing cycle time meet the customer's need for a high quality, low-cost product?" The answer reminds us of the geometry lesson, "The shortest distance and most efficient path between two points is a straight line."

"Cycle Time!" What does this mean? As the pace of the world quickens, the value of being first to market with innovative solutions is the key to true competitive advantage. This is true in the commercial marketplace and it is also true in the military market.

Consider the lessons of Desert Storm. Texas Instruments (TI) was fortunate enough to participate in the GBU-28 Bunker Buster Program. A new system was needed to deal with deeply buried command and control bunkers that were beyond the reach of existing systems. The need was great, the time was short, and the only solution was to innovate a solution in an unprecedented short period of time. A team of government and industry people came together sharing the common objective of solving a difficult technical challenge in a breakneck race against time. Personal interests were set aside as were traditional approaches, with long hours being the norm. The team worked to trade time against everything (cost, risk, performance). Reuse of existing subsystems offered the only answer. However, the pieces would have to be integrated in a very innovative way to achieve the desired results.

The result was the GBU-28 Bunker Buster that was conceived, developed, tested, and deployed in approximately 28 days. This was less time than had ever been dreamed possible. The mission was accomplished and the GBU-28 played a significant role in the ending of the war. It was certainly not the only factor, but the fact that Iraq surrendered one day after the system destroyed a deep command bun-

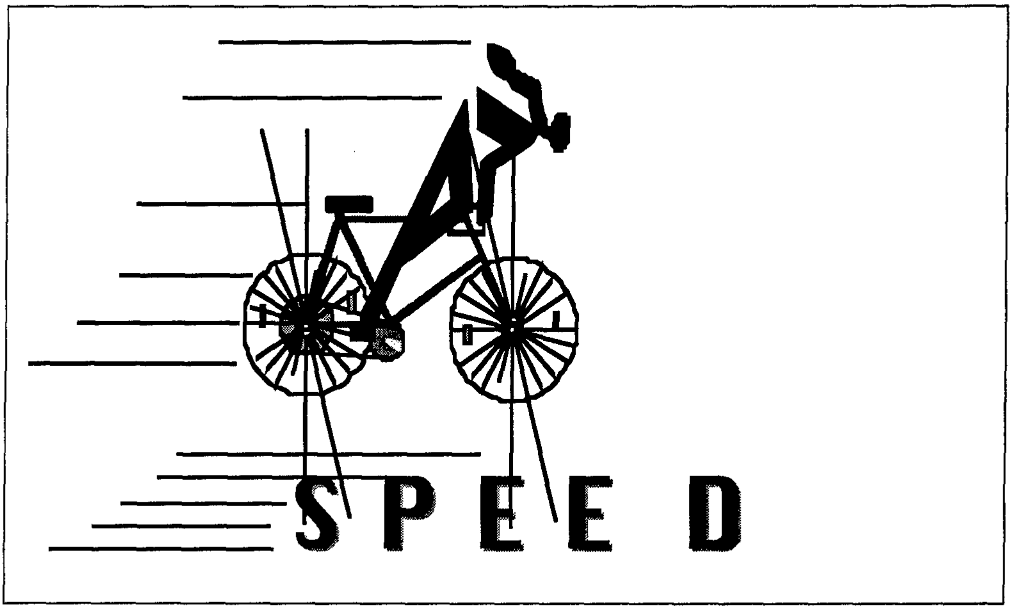

Figure 1. "Cycle Time"

ker was probably not a coincidence. The entire effort made a difference and the reason was *time—blinding fast cycle time.* The system performed when it was needed but there were also other benefits: the cost was low because the entire effort was accomplished in such a short period. Also, the quality and reliability was high because it was made of existing proven subassemblies. A common thread emerges when this experience is compared with other similar ones: If you can drive down cycle time, cost and quality will improve. So the bottom line is that *time is a precious commodity and has value*—it is true every time a new product arrives well in advance of the competition.

Wasted motion is expensive, compromises quality, and results in noncompetitive products and services. The result is that instead of giving the customer a competitive advantage, the wasted motion actually results in customer dissatisfaction. Achieving customer satisfaction will dictate company survival. The companies that meet their customers' needs of low cost and high quality will be the companies that maintain prominence. Cycle time, speed,

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and improvement methodology is the key in fulfilling customer needs. Michael Porter of the Harvard Business School, quoted in a recent *Wall Street Journal* article by William M. Bulkeley says, "Speed has become crucial to getting ahead internationally. It's gone from a game of resources to a game of rate-of-progress." He says, "Competition today is a race to improve." In his article he quotes Kim Sheridan, chairman of Avalon Software Inc., a Tucson, AZ, maker of software, by saying: "It's not the big companies that eat the small: It's the fast that eat the slow." The benefits of speed are becoming more and more recognized by companies in America and throughout the world.

In order to meet critical customer needs of reduced cost and improved quality, they realized a key methodology in achieving these demands lies in properly reducing cycle time. By evaluating a process, unrequired tasks can be identified and removed. Some examples of the tasks that are undesirable are audits, inspections, handoffs, signature approvals, to name a few. These tasks would be identified as wasteful steps, non-value-added curves in a road or deviations in a straight line path. In other words straighten out the curves from point A to point B.

Merely performing the same process steps faster—applying automation, employee overtime, or extended shifts, to mention a few of traditional methodologies—do not reduce cost or improve quality. These actions in fact drive up overhead, add cost, and do little to address our customers' real needs. The same curves are in the road.

Although this methodology may produce products faster, it overlooks other key competitive ingredients of cost and quality. Cycle time improvements, utilizing the proper methodology, will have a positive impact on cost and quality. Eliyahu M. Goldratt states in his book *The Goal* that when applying the theory of constraints, one always must evaluate critical path items and perform the tradeoffs that best meet customer needs. Be very careful to seek process improvements that have a favorable impact on cycle time, quality, and cost.

For example, if one seeks a solution that gets us quality at a higher cost, it is not a competitive solution (it may require additional capital, more inspections, stretching cycle time, etc.). Or, if one arbitrarily reduces cycle time (i.e., stops inspection without improving the process) then poor quality will be passed to the customer.

Both situations will increase cost or loss of customer confidence.

Using the proper methodology will favorably effect speed, cost, and quality. The proper methodology encompasses all phases of the product need: customer needs (teaming), and manufacturability, teaming with all skills of the process:

- standardization,
- material,
- processes,
- simplicity of design, reduction of part numbers to a minimum,
- reusability,
- reuse of existing designs,
- reuse of existing manufacturing processes,

- reuse of existing test equipment,
- reuse of existing documentation and plans,
- supplier involvement and teaming at the earliest point of product, and
- combine tasks and removation of handoffs

Texas Instruments is striving to maximize design standardization and strictly adhering to the integration of these processes into all product development phases. Greater emphasis is also being placed on design for manufacturing capabilities. After all, if a product is not going to be produced and used by a customer why develop it in the first place? Development should encompass all phases of the product need.

When applying the proper methodology to existing processes one must first truly understand the existing process. Mapping the current process is critical in identifying all the curves in the road. Arrive at an understanding of why a process either needs the curves, because of current design, or establish the reason for removing the curves from the process. Process standardization will enhance cycles of learning. Companies that have a well-

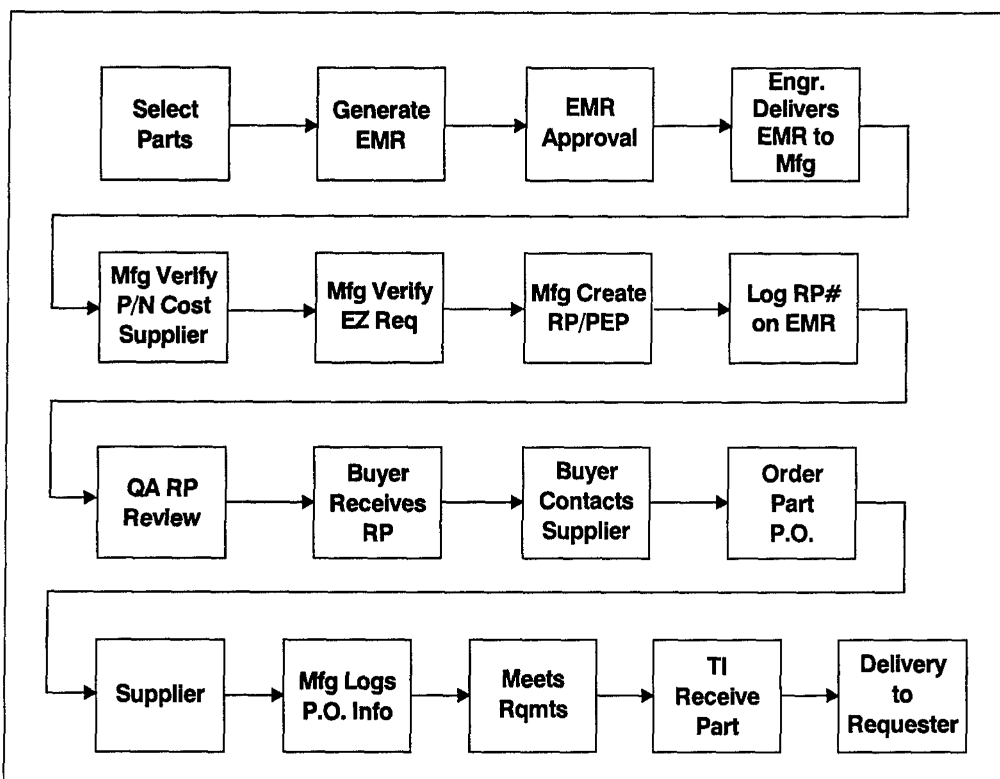

Figure 2. Engineering and MRO Material Purchasing

integrated design standardization focus will tend to have higher value-added processes. The processes will be simpler, thus reducing variation (higher quality). In other words, processes which require individual "heroics" have a greater number of curves, higher rate of variation (lower quality). Companies that have a well-integrated design standardization focus will have fewer processes, but the processes will be well understood and will be much more effective in meeting the customers needs. Processes that are determined to be best in class will be used and are improved over time.

Figure 2 shows a real-life example of redesigning a process with an emphasis on cycle time. The figure illustrates the process of ordering maintenance, repair, operational and engineering material. The process consisted of seventeen steps. The cost was $103 per transaction and required a cycle time of four to six weeks. Upon reviewing the process it was determined that only four steps were required to meet customer needs. Figure 3 shows the revised process with only the necessary steps. The revised process demonstrates a cycle time for engineering material of three to eight days. Maintenance, repair, and operational material currently has a cycle time of one day. Transaction costs have been reduced to less than $5 per transaction. The quality level consistently

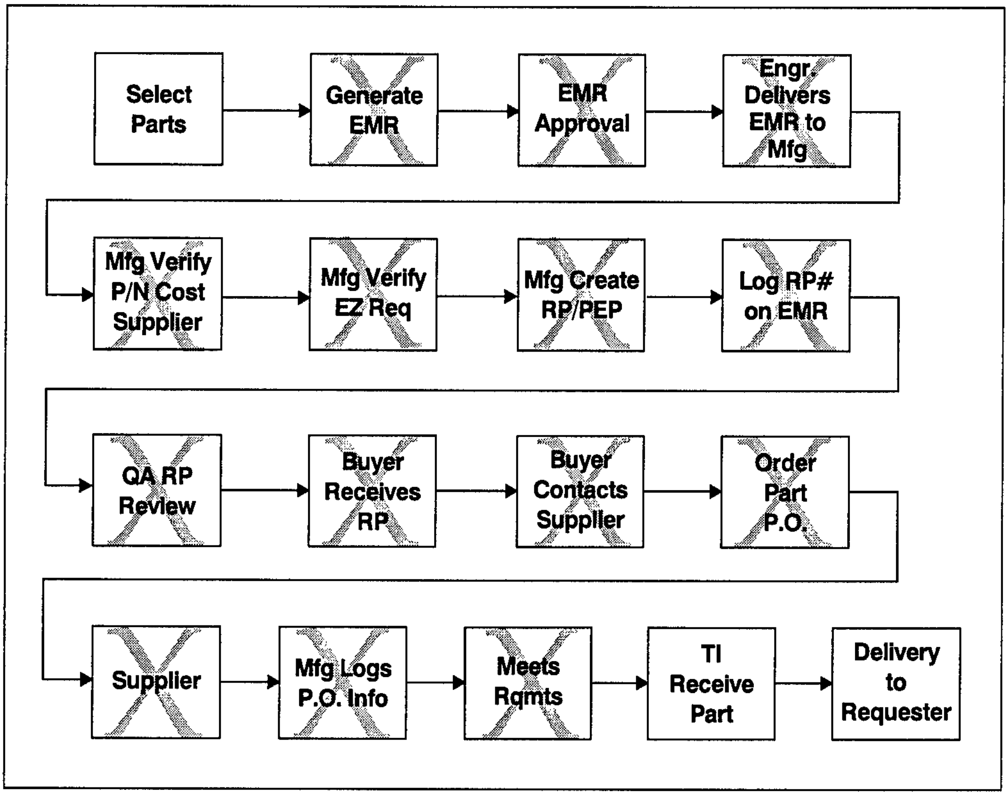

Figure 3. Express Buy Process

maintains 6 sigma.

The concept is relatively simple; remove the inefficient process steps and keep the steps that are only absolutely required (value-added steps). Value added steps are defined as steps the customer is willing to pay for. Since processes don't start and stop neatly at functional boundaries, the process usually never gets optimized. In fact, by optimizing a given function the process can, in many cases, degrade or become suboptimized.

In order to effectively reduce cycle time, complete processes have to be reviewed, not just functions. Typically, businesses are organized around functions. This is called a hierarchical functional organization. Functional organizations work to optimize a functional expertise. The entire recognition and reward structure is designed around creating this behavior. In today's environment of speed, this bureaucratic culture is not conducive to the behavior required for incremental, fast, dynamic, ongoing change required by today's customer.

Industry is attacking this hierarchical culture by introducing teaming concepts. These concepts are designed to give businesses a process focus. The teaming models are designed to break down traditional organizational boundaries and remold these functions into skills that are required by the process. These models obviously attack the heart and soul of traditional management practices. Moving a company from a functional improvement model to a process improvement model is a key in reducing the wasted motion involved in producing a product. Obtaining the corporate environment that will enable diverse, highly skilled people to focus on establishing and improving processes that will produce products that truly meet customer needs is vital.

Great athletic teams perform with flawless precision, very little wasted motion, and few mistakes, and they continue to exceed records of past performance. Industry, by better applying teaming dynamics to harness the workforce when they apply the proper cycle time methodology, can lift customer satisfaction to a new all time high. The teaming business of the future must learn to relish change, question everything, think outside the box, and never stop learning. Work to master the dynamics of creating a culture advantageous to teaming and empowerment. The successful company must want customers to be embarrassed to even think about doing business with someone else.

Time is a precious commodity and has value. It is there every time a new product arrives well in advance of the competition. Applying the correct methodology of cycle time, cost, and quality is key to customer satisfaction and product success. The bottom line is—*blinding speed equals competitive advantage!*

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