COMPLEXITY: *A COGNITIVE BARRIER TO DEFENSE SYSTEMS ACQUISITION MANAGEMENT*

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Department of Defense acquisition policy used to treat the modification of existing systems to meet new or changing requirements as an aberration rather than the norm. Little attention was paid to management of iterative processes such as preplanned product improvement, spiral development, or evolutionary acquisition. The recent shift in policy toward evolutionary acquisition, as the preferred approach to meeting operational requirements, will require a paradigm shift regarding management of defense systems acquisition programs. The Advanced Program Management Course offered at the Defense Systems Management College must be modified to support that shift.

The environment in which defense systems acquisition occurs has undergone significant change. The end of the Cold War has led to extreme reductions in defense spending in the United States and around the world. Downsizing of military forces and consolidation of the defense industry here and abroad have significantly altered the structure of the public and private sectors. The confluence of budgetary reductions, absence of a consistent, long-term, singular military threat, and expansion of the civil marketplace as a driving force behind technology has resulted in recent Department of Defense (DoD) adoption of an evolutionary acquisition process as the preferred method for meeting operational requirements (Gansler, 1999). Despite recognition of the need to do things differently, some things remain unchanged and, to a large extent, unrecognized.

Real-world defense systems acquisition problems are largely nondeterministic in their behavior.[1] Decisions concerning the acquisition process and its products can and do result in unanticipated outcomes. This is true regarding problematic situations encountered in implementing systems acquisition policy as well as in efforts to match defense system capabilities with operational and support requirements.

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Defense systems cost American tax-payers billions of dollars. These programs periodically undergo intense media scrutiny and political debate. The resulting impact on individual acquisition programs can be chaotic. Effective management of defense system acquisition under these conditions clearly requires a high degree of technical, business, and political acumen. More important, it also requires an understanding of the demands that such complicating factors place on managerial activities. The research reported herein was aimed at investigating the extent to which individuals undergoing systems acquisition management training at the Defense Systems Management College (DSMC) are prepared to meet those demands.[2]

While this article focuses on the challenge facing acquisition managers in the DoD, that challenge is not unique. It is reflective of the impact that technology has had on society at large. In modern times, technology has been the catalyst for unprecedented speed and magnitude of changes that quickly outstrip society's ability to keep pace. Humanity's frequent inability to effectively manage large-scale systems is readily apparent.[3] The combination of technical, organizational, and personal perspectives when faced with design and management of such systems results in solutions marked by:

- overconfidence in current technical knowledge;
- failure to recognize interactions among system components that have been designed relatively independently; and
- failure to anticipate people problems and human responses in crises. (Mitroff & Linstone, 1993.)

Research Context

Problematic Situations: A Matter of Scale

We are not concerned here with resolution of problems that can be categorized as routine—those that require limited mental processing and whose outcome is readily observable. Rather, we are interested in problems characterized by effects that are distant from causes in time as well as in space—problems with few, if any, obvious trigger points that can be used to produce significant and lasting change. Milan Zeleny (1977) recognized the role of scale in what we will refer to herein as "problematic situations" when he wrote that human systems management is not interdisciplinary or multidisciplinary, it does not attempt to unify scientific disciplines, it transcends them. Such is our view of complexity and the cognitive challenges it presents in all forms of human endeavor. Those challenges are of such scale that a trans-disciplinary paradigm is required for effective problem resolution.

Complexity: A Matter of Perspective

As yet, there is no agreed-upon explicit definition of complexity, although there are various operational descriptions (Cambel, 1993). This research effort proceeded from the presumption that complexity in the defense systems acquisition process is a matter of perspective; *it resides within the observer, not the system under investigation*. It is the observer's inability to grasp the interplay of multiple factors and events that lead to "complex" problems, issues, or systems. We believe there is strong support in the literature for such a position and the need to make a clear distinction between use of the word "complex" as an adjective and our focus on the word "complexity" as a noun. *In our view, complexity is a result and not a cause of confusion regarding the system, situation, or issue under consideration.*

The Role of the Observer

According to Fischer (1991), the first to emphasize the peculiar situation of the observer was R. J. Boscovich in "*De Spatio et Tempore*" written in 1758. In Fischer's words: "Boscovich, a forerunner of Einstein, was the first to propose that the world must be described relative to an observer. Moreover, Boscovich claimed that the observer can never observe the world as it is—only the interface (or difference) between him and the world." This notion of the observer's role was central to America's preeminent nineteenth century philosopher, Charles Sanders Peirce, who wrote about the triadic relationship between object and subject or "interpretant" through sign or symbol (Paynter, 1968; Hoopes, 1991).

The basic triadic act is naming—creating a symbolic bridge between subject and object. It is the interpretant, the observer, who constructs the bridge. Without an observer, there is no observation. It follows that if the observer names the object, complexity is in the observer's mind, not in the object under investigation. Despite these early insights regarding the nature of complexity, the philosophical bent growing out of the machine age resulted in an overshadowing emphasis on objectivity and the deterministic, mechanistic, and reductionist perspective of late nineteenth and early twentieth century science. Mitroff and Linstone (1993) maintain that separation of subject and object is a paradigm that underlies much of the approach to physical, social, and management science education even today.

The ideas of Boscovich and Peirce regarding the role of the observer resurfaced with the emergence of systems science following World War II. Several proponents of systems science did take specific note of the observer's role in characterizing the nature of systems. C. West Churchman (1968) wrote that it is a silly and empty claim that an observation is objective if it resides in the brain of an unbiased observer. W. Ross Ashby (1956) defined a system as any set of variables that the observer or experimenter selects from those available on the "real machine." Accordingly, any system definition is only a model of reality constructed subject to the observer's limitations of purpose and thought. Charles Francois (1997) refers to Heinz von Foerster as originator of the statement that objectivity is the cognitive version of the physiological blind spot. Robert Rosen (1977) specifically states that complexity is in the eye of the observer.

"The basic triadic act is naming—creating a symbolic bridge between subject and object."

The Demands of Complexity

The aim of classical nineteenth century science was to discover in all systems some underlying simple level of operation where deterministic and time-reversible laws of nature applied. In the classical perspective, there was a clear-cut distinction between what was considered to be simple and what had to be considered as complex. The concept of complexity within systems thinking has evolved considerably since that time (Cambel 1993, De Greene 1993, Klir 1991.) Several schools of thought have arisen during the latter half of the twentieth century to address the management of complexity (Warfield, 1996a.)

We found the following words of Warfield (1995a) to be the most powerful reason for the thrust of our research effort. They clearly identify where complexity resides and underscore the need for a paradigm shift in the managerial approach to problematic situations. "To misplace the origin of complexity in the object of inquiry, instead of in the mind of the observer, is to commit an error that is unlikely to be undone.... *If, however, it is correctly realized that complexity is in the mind of the beholder, the possibility of reducing complexity through learning processes comes to the fore*." (Emphasis added.) Thus, we embarked upon a line of research aimed at identifying cognitive barriers to be overcome if we are to be successful in understanding the nature of complexity. And, we chose to pursue that research in an educational institution dedicated to improving the systems acquisition management process.

> **"More than 875 individuals from seven acquisition management courses participated in the research project."**

The Research Question and Methodology

We sought to find an answer to the following question: Are members of the defense acquisition workforce prepared to meet the demands of complexity?

Input for analysis was gathered through questionnaires administered to highly schooled engineering- and management-oriented government employees responsible for the acquisition and life-cycle support of defense systems. Virtually all participants were college graduates with 10 or more years of on-the-job experience. Most held bachelor's degrees in an engineering or business discipline and many held master's degrees as well.

Study participants included acquisition professionals attending the 14-week Advanced Program Managers Course (APMC) and members of the faculty at the DSMC located at Fort Belvoir, VA. The College is considered to be a premier center for learning about the DoD systems acquisition process. Successful completion of APMC is considered essential for selection as a program manager of a major defense systems acquisition program.

The principal research effort comprised three separate studies conducted between January 1996 and February 1999. More than 875 individuals from seven acquisition management courses participated in the research project. A combination of content analysis as described by Weber (1990) and nonparametric statistical analysis as described by Siegel and Castellan (1988) was selected as an appropriate set of procedures for analyzing most participant responses to self-administered survey instruments. Random sampling and inferential statistical analytical techniques were applied to the extent practical. Significant reliance on nonrandom purposive sampling permit us to describe what was discovered, but not to state generalizable conclusions concerning the associations or patterns uncovered. This restriction was deemed acceptable since participant demographics generally reflect the composition of the DoD acquisition workforce.

Results

Barriers to the Interpretation of Structural Graphics

The first study focused on interpretation of graphical displays designed to aid in the management of problematic situations. Such situations are comprised of multiple interrelationships difficult to convey through text alone. To enhance the practical benefits of this research effort, we chose to use graphical displays noted for their track record as viable management tools. A set of graphical displays known as interpretive structural models, met this requirement. They are the products of a process called interactive management (IM) developed by John N. Warfield, a pioneer in the management of complexity through systems design. The IM process, products, and scientific foundations are described in the many publications of Warfield and his colleagues (Warfield, 1990, 1996b).

Graphical displays can be an extremely efficient means of communication if the viewer understands the rules of construction. However, rules for proper construction of interpretive structural graphics are not easy to articulate. Furthermore, visual skills, unlike talking, reading, and writing skills, have been left dangling by our Western educational system (Eisner, 1993). To presume intuitive understanding of graphical displays is erroneous. Research in the field of visual literacy points out that while looking may be a given, seeing and understanding is an achievement (Feinstein & Hagerty, 1994).

We limited our investigation to an interpretive structural model designed to facilitate problem definition and resolution. It is the model most often developed first in the IM process and the one most often subject to misinterpretation by first-time viewers. The graphical display of this model is called the "problematique" (Warfield & Perino, 1999). The purpose of this study was twofold: first, to identify common misperceptions of the problematique among first-time viewers; and second, to identify likely causes for their misinterpretation of graphical syntax. It was anticipated that such information would facilitate development of educational material aimed at increasing viewer comprehension. More than 475 acquisition professionals participated in this research.

"Graphical displays can be an extremely efficient means of communication if the viewer understands the rules of construction."

Results showed significant misinterpretation of the problematique. Participants had little or no prior training in the use of this display. But their inability to correctly interpret the display's format and underlying logic, even when written instructional material was provided, was surprising. The average score among the 170 respondents asked to interpret a problematique without benefit of instruction was 22 percent. The average score among 314 respondents with access to written instruction was only 45 percent. Analysis of narrative responses to questions about the meaning of the display led us to conclude that participants were predisposed to reductive reasoning and emphasis on cause and effect as a principal mode of thought. To the extent that this conclusion is valid, it provides cause for concern regarding effective management of the DoD systems acquisition process. That process is lengthy and complicated. It is subject to technical as well as political perturbations. Both the process and its products are socio-technical in nature. As such, they are emergent, not mechanistic in behavior. Taking management action based on a paradigm of determinism invites repeated failures in program execution and a terrible waste of national resources.

"Taking management action based on a paradigm of determinism invites repeated failures in program execution and a terrible waste of national resources."

Managerial Assumptions about the Nature of Complexity

The second study focused on acquisition workforce participant opinions regarding the nature of complexity. Warfield (1998) identified a series of assumptions he believes people make about the nature of complexity. He believes these assumptions interfere with the effective management of large-scale problematic situations to such a degree that he has labeled them as "killer assumptions." Warfield also identified a series of demands that complexity places on management. The demands of complexity are the antithesis of the killer assumptions. The purpose of this second study effort was to assess how widely each, if any, of the killer assumptions might be held among individuals responsible for managing the acquisition and life-cycle support of national defense systems. This study included 85 APMC students and 28 faculty at DSMC and was completed in December 1998. Killer assumptions and their antithetical demands of complexity are listed side by side in Table 1. The percentage of respondents selecting each alternative is shown in parentheses.

The total number of killer assumption statements chosen by respondents is displayed in Figure 1. Totals ranged from a low of 0 to a high of 14. The most frequent number of killer assumption statements chosen by any one individual was three. The average number was four.

The four most frequently chosen killer assumption statements deal with confidence in human learning powers, the location of complexity, belief in the intellectual capacity of executives, and the assumption that natural language is adequate to represent complexity (Table 1). In combination, these four suggest that resolution of large-scale problems presents no unique challenge. The two most frequently combined killer assumptions were that human learning powers are independent of what is to be learned and that complexity is in the system being ob-served. This is worrisome, as it indicates that overcoming cognitive barriers to the management of problematic situations will be a daunting task. It was encouraging to find that faculty were not as likely to choose killer assumption statements as were the course attendees. As Figure 2 shows, the maximum number of killer assumptions chosen by any one faculty member was six and the most frequent number chosen was three.

Table 1. Percentage of Respondents Choosing Killer Assumptions versus Antithetical Demands of Complexity

Killer Assumptions	Demands of Complexity
Human learning powers are independent of the scale of what is to be learned. **(62 percent)**	Individuals cannot resolve complexity simply by thinking about it or discussing it in unorganized group conversation. **(38 percent)**
The site of complexity is in the system being observed. **(46 percent)**	The complexity of a situation is distributed among many minds. **(54 percent)**
The executive has the intellectual capacity to comprehend: • all of the factors that are relevant to an executive decision; • how the various factors are interrelated in a problematic situation; • what alternatives are relevant when it is time to make a choice; • how to prioritize the alternatives; and • at what time action should be initiated. **(44 percent)**	Complexity demands that organizations accept the inevitability of executive inadequacy to resolve complexity, as an inherent property of every human being. **(56 percent)**
Natural language is adequate to represent complexity. **(44 percent)**	The inadequacy of natural language (e.g., linearity) must be recognized; graphical nonlinear logic must be widely adopted in the domains of complexity to help overcome that inadequacy. **(56 percent)**
Representation of complexity through metaphors related to common quantitative formalisms from physical sciences is strongly contributory to the resolution of complexity. **(36 percent)**	Complexity demands portrayal of the logic underlying the problematic situation. **(64 percent)**
There is no reason to provide any special infrastructure at work to deal with complexity. **(30 percent)**	A workplace infrastructure dedicated to resolving complexity would satisfy a major demand of complexity. **(70 percent)**

Table 1. Percentage of Respondents Choosing Killer Assumptions versus Antithetical Demands of Complexity (continued)

Killer Assumptions	Demands of Complexity
Academics should be free to call any subject that they choose a "science" with no institutionally established requirements and standards for linguistic quality control. **(23 percent)**	The word "science" must be restricted to those fields in which archival history, established laws, adequate empirical evidence, and adequate metrics have been established to form a science. **(77 percent)**
The extent of valid application of common quantitative formalisms from physical sciences into socio-technical arenas is very large, and can be organized so that it is almost automatic. **(23 percent)**	Advocacy of unvalidated metaphors of formalisms from physical science must be tempered; justification and empirical evidence must be provided to support such advocacy. **(77 percent)**
There is no need to allocate space specifically for the purpose of portraying complexity. **(23 percent)**	Complexity demands that workspace allocation be designed especially to facilitate human learning. **(77 percent)**
Normal processes are sufficient to enable description and diagnosis of problematic situations involving high complexity. **(22 percent)**	The design of group processes must suit the character of complexity, rather than simply using conventional processes or allowing NO process design. **(78 percent)**
It is appropriate to discuss science and technology as though there are no essential distinctions between them. **(21 percent)**	Complexity demands that technology used to help resolve problematic situations shall have been founded in science, and not just imposed by highly vocal advocates. **(79 percent)**
There is no need for empirical evidence to justify assumptions of relevance when designing processes to support resolution of complexity. **(17 percent)**	Scientifically respectable evidence must be applied in designing processes to support resolution of complexity. **(83 percent)**

Table 1. Percentage of Respondents Choosing Killer Assumptions versus Antithetical Demands of Complexity (continued)

Killer Assumptions	Demands of Complexity
Simple amalgamation of disciplines will relieve disciplinary shortcomings mands in considering comprehensive domains. **(15 percent)**	Interdisciplinary programs must be designed to meet complexity's de- for learning efficacy. **(85 percent)**
There is seldom any reason to give the choice of types of relationships that are to be used in studies the same level of effort and depth of selectivity that are given to the elements that will be related (e.g., in model development). **(14 percent)**	In problematic situations, the choice of relationships to be applied shall have as much prominence in the thinking of practitioners as does the choice of elements that are to be related. **(86 percent)**
The findings from behavioral science about individuals, groups, and organizations are too "soft" to have a major role in the management of organizations. **(11 percent)**	Linkages between thought leaders from the past and practices invoked in organizations must be widely under-stood, and taken into account in self-regulation of human behavior. **(89 percent)**
If information comes from a "prestigious" source, it need not be questioned. **(5 percent)**	The authority of "prestigious institutions" must be tested against the scientific base that ought to be provided to support that authority. **(95 percent)**
There is no need for empirical evidence to justify assumptions of relevance when designing processes to support resolution of complexity. **(3 percent)**	Scientifically respectable evidence must be applied in designing processes to support resolution of complexity. **(97 percent)**

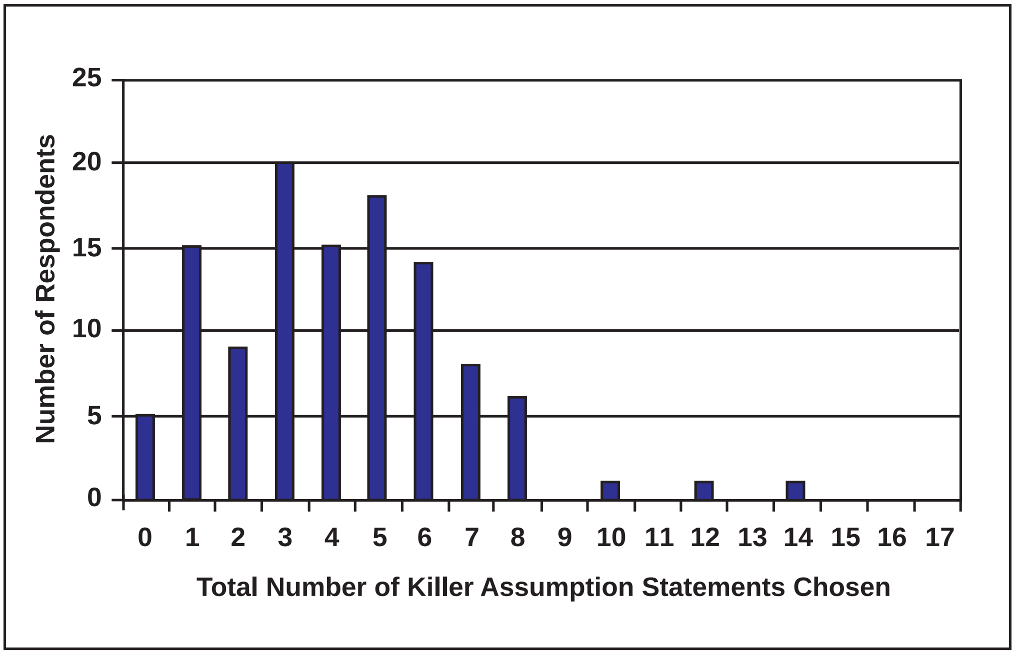

Figure 1. Total Number of Killer Assumption Statements Chosen by Respondents

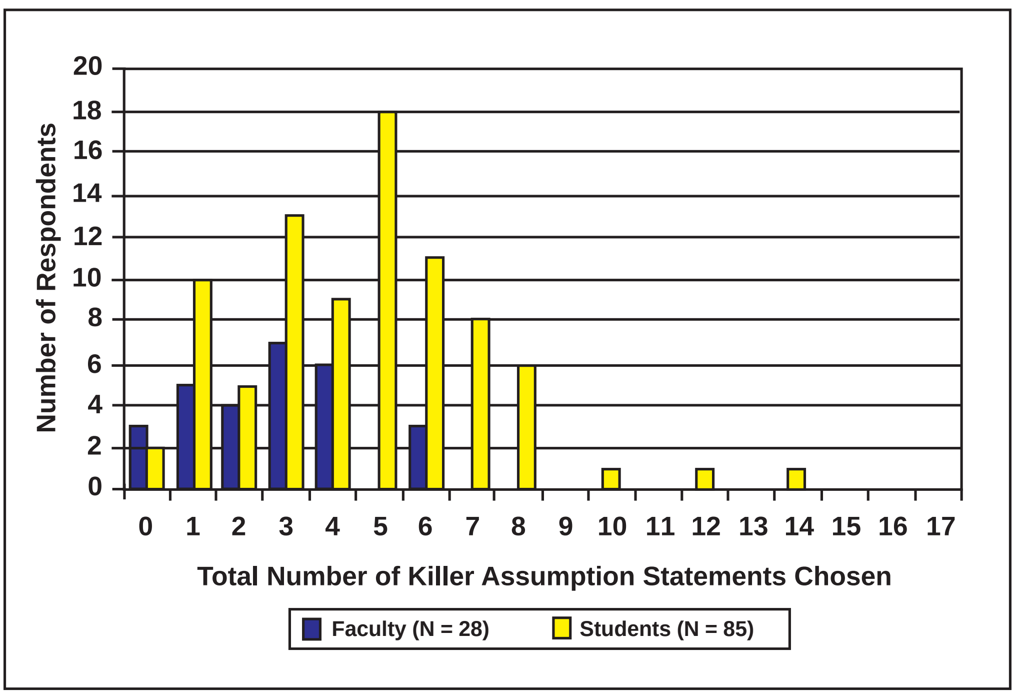

Figure 2. Number of Killer Assumption Statements Chosen by Faculty and Student Respondents

It's important not to discount Warfield's hypothesis that educational institutions fail to prepare students to deal adequate-ly with the demands of complexity (Warfield, 1995b, 1996c). This is particularly so given the apparent level of faculty confidence in human cognitive abilities. More than 60 percent of the faculty participants in this study agreed with the statement that human learning powers are independent of the scale of what is to be learned. Yet, the inability of the human mind to process more than a few bits of information simultaneously is well known (Waller, 1982; Miller, 1956; Simon, 1974; Warfield, 1988). The tendency is to underconceptualize interrelationships, thereby avoiding cognitive overload. Underconceptualization leads to insufficient understanding of problematic issues by any single individual or group of individuals with all the unfortunate outcomes that result (Warfield, 1991).

THE NATURE OF SYSTEMS AND PROBLEM SOLVING

The third study involved more than 300 acquisition professionals and focused on obtaining their opinions regarding the nature of systems and problem solving. Results of the first two studies had led us to wonder about participants' perspective regarding systems theory. As previously stated, most survey participants held undergraduate and graduate degrees in engineering or business management subjects. The curriculum of the systems acquisition management course they were attending addressed both theory and practice in systems management tools and techniques, yet survey responses had often reflected a simplistic approach to problem solving. We therefore determined that important insights about this phenomenon could be gained by obtaining APMC attendee responses to the following three open-ended questions:

- What definition of "system" do you think is most useful?
- What does "problem solving" involve?
- How might "system behavior" be best understood?

Input was obtained by administering a one-page questionnaire and applying content analysis procedures to the responses. Analysis disclosed a predominantly Newtonian perspective among the participants.[4] Well over half the respondents felt that system behavior could be best understood through observation and analysis. Almost the same proportion described a problem-solving process that did not include getting feedback to determine if the chosen solution was working. These results gave weight to concerns raised during our earlier studies that acquisition professionals attending APMC were overly focused on near-term observable outcomes and decision making, and less so on actual problem solving.

AGGREGATE FINDINGS

This research effort sought to answer this question: Are members of the defense acquisition workforce prepared to meet the demands of complexity? Three studies were conducted. The purpose of the first was to determine if first-time viewer comprehension of a problematique can be improved by providing written instruction. The purpose of the second was to determine which if any of Warfield's killer assumptions are widely held among defense systems acquisition professionals. The purpose of the final study was to gain insight to acquisition professionals' view of systems management. Combining the results of those three studies led us with the following aggregate findings:

- Acquisition professionals share a predisposition for reductive reasoning and a reliance on a simplistic linear approach as a principal mode for managerial actions (studies 1 and 3).
- Acquisition professionals are very confident of the capacity for human learning regardless of the scale of what is to be learned (study 2).
- There is considerable difference of opinion among acquisition professionals concerning whether the site of complexity is intrinsic to a system under observation or resident in the mind of the observer (study 2).

CONCLUSIONS AND RECOMMENDATIONS

Results of the research support a contention that defense systems acquisition professionals represented by the research sample are not adequately prepared to deal with the demands of complexity when attempting to manage the nondeterministic aspects of large-scale systems acquisition programs. The prevailing strategy for systems acquisition is Newtonian in its origin and linear in its essential characteristics. It embodies analysis and control of observable outcomes and drives managerial attention toward near-term time horizons. Such a strategy may be appropriate for well-defined mechanistic systems, but is inappropriate when attempting to manage problematic situations encountered during the defense systems acquisition process.

The curriculum of the APMC at DSMC follows DoD policy that, until recently, emphasized a linear flow of activities starting from the establishment of war fighter requirements, through systems development, production, life cycle support, and ending with disposal. Relatively little attention has been paid to challenges faced when existing socio-technical systems must be modified to meet new or changing requirements. Iterative processes such as preplanned product improvement (P^3I), spiral development, or evolutionary acquisition have been treated as aberrations rather than as the norm. Such an approach flies in the face of reality given current emphasis on extending the life of existing systems and the evolutionary development of new systems. There is a pressing need for a paradigm shift regarding management of defense systems acquisition programs. Curriculum that places undue emphasis on objectivity and the deterministic, mechanistic, and reductionist perspective of late nineteenth and early twentieth century science must be replaced with one that prepares graduates to operate within the nonlinear, nondeterministic reality of large-scale socio-technical systems. The following actions are recommended for DSMC management to help bring about the transformation:

- Make provisions for educating faculty, staff, and students regarding the demands of complexity to include learning theory and human learning capacity under varying conditions.

- Increase emphasis within the curriculum on the use of science-based and empirically tested methods for resolving problematic situations.

- Augment the functional faculty organization to facilitate a transdisciplinary approach to the application of management and leadership principles.

These actions will help bring about the educational transformation. But a total transformation will be difficult as long as acquisition professionals continue to overestimate human cognitive ability to contend with large-scale problematic situations and fail to recognize that complexity is endemic to the observer rather than an intrinsic system characteristic.

The findings, conclusions, and recommendations presented herein pertain specifically to members of the defense systems acquisition workforce attending the 14-week APMC at DSMC but could possibly be generalized across the entire acquisition workforce. APMC students may be unique in the level of education and experience they bring to the academic environment, but they are the products of America's educational institutions. There is abundant evidence from this study to suggest the need for research regarding the educational paradigm underlying engineering and business management education in the United States. Results of such research may identify a need for organizational change and curriculum reform within our colleges and universities to produce graduates able to meet the demands of complexity as they attempt to resolve the large-scale socio-technical problems facing our nation.

POSTSCRIPT

A survey of acquisition professionals attending the APMC and graduates of the Executive Program Managers Course (EPMC) was conducted during March and April of 2000. This survey focused on the four "killer assumption" statements most frequently chosen by prior respondents and the three open-ended questions about the nature of systems and problem solving. Those tend to reinforce the recommendations being made herein.

For example, the APMC survey participants were attending the latter stages of a revised 14-week course designed to increase emphasis on "real world" acquisition problems with a problem-solving model that included a feedback loop. Yet only 39 percent of these survey respondents mentioned getting feedback when they responded to the question: What does "problem solving" involve? In response to the same question, only 24 percent of respondents among EPMC graduates included obtaining feedback on implemented solution in their answer. Although the EPMC graduates did not have the benefit of attending the revised APMC, such a potentially low attention to follow-up among major DoD systems acquisition program managers and deputy program managers is quite worrisome. These results suggest a need for increased emphasis on post-decision follow-up as part of the problem-solving process taught at DSMC.

In addition, belief in human learning powers was very strong in both groups. Seventy-two percent of APMC attendees and 67 percent of EPMC graduates favored the "killer assumption" that human learning powers are independent of the scale of what is to be learned. While this response may be biased due to association with the DSMC educational environment, it does suggest the possibility of over-confidence regarding the capacity for dealing with large-scale systems. In this regard, it is interesting to note that the APMC respondents had a higher regard for executive capabilities than EPMC graduates did. Forty-nine percent of the APMC respondents, as opposed to 33 percent of the EPMC respondents, favored the following "killer assumption" statement: The executive has the intellectual capacity to comprehend:

"...one could hypothesize that increased "real world" experience may tend to reduce an individual's faith in their own ability to manage problematic situations."

- all of the factors that are relevant to an executive decision;
- how the various factors are interrelated in a problematic situation;
- what alternatives are relevant when it is time to make a choice;
- how to assign priority to the alternatives; and
- at what time action should be initiated.

Since most EPMC graduates have also attended APMC, one could hypothesize that increased "real world" experience may tend to reduce an individual's faith in their own ability to manage problematic situations. These results suggest that the current effort to include more "real world" learning experiences in the APMC curriculum is a step in the right direction.

ENDNOTES

1. A growing body of literature provides ample support for such a premise. See, for example, Cambel (1993), De Greene (1993), Kiel (1994), and Waldrop (1992) for contemporary thoughts by systems thinkers. See also Fenster (1999) for a telling example of an acquisition management disaster within the Department of Defense.

2. The Defense Acquisition Workforce Improvement Act (DAWIA), Public Law 101-510, Title 10 U.S.C., was enacted to improve the effectiveness of the personnel who manage and implement defense acquisition programs. As part of the fiscal year 1991 Defense Authorization Act, it called for establishing an Acquisition Corps and professionalizing the acquisition workforce through education, training, and work experience.

3. Socio-technical system failures such as Chernobyl, *Challenger*, and fratricide in the Gulf War provide tragic reminders of large-scale system mismanagement. Similar failures, with arguably less tragic consequences, are reported almost daily by the world news media.

4. By Newtonian, we mean an investigative approach, born in the 17^{th} century, that proved successful working with systems characterized by a very small number of variables, a high degree of determinism, and suitable for analytical treatment. Problems with such characteristics have been referred to as problems of organized simplicity (Klir, 1985).

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