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DEFENSE ACQUISITION REVIEW JOURNAL



A NOTE FROM THE EXECUTIVE EDITOR

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PROBLEM SOLVING: COLLABORATION AND TEAMWORK— THE KEY TO SUCCESSFUL WARFIGHTER CONTRACT SUPPORT

*Lt Col (Sel) Gilberto Rosario, USAF, Joseph Vernon,
William Kleiner, and Matthew Popham*

The Defense Contract Management Agency (DCMA) and the Rolls-Royce Corporation discovered that through close collaboration and teamwork, day-to-day business issues that previously required significant time and resources to be resolved instead quickly started to disappear or to require less effort to be resolved. This article discusses the underpinnings of a successful government and contractor collaboration through the discussion of DCMA's contract management services, the contractor's environment, technical challenges realized within manufacturing and business systems, followed by a look at problem solving approaches and philosophies, all of which led to significant improvements in both the quality and on-time delivery to the warfighters at a fair and reasonable price.

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A BUSINESS MODEL FOR DEFENSE ACQUISITION UNDER THE MODULAR OPEN SYSTEMS APPROACH

Eugene Gholz

This article briefly describes a business model that companies may apply to develop, produce, and sell avionics to the Department of Defense under a Modular Open Systems Approach (MOSA). Recent acquisition reforms have

encouraged the use of MOSA, and the defense industry will need to adapt to the new style of acquisition. A business model summarizes the way a firm earns profits sufficient to remain in business: it describes core competencies, principal activities, cost structure, and expected revenue stream. The model proposed here suggests that firms can succeed under the new framework, but that MOSA entails some drawbacks for both industry and the government that may limit its applicability to a relatively small subset of programs.

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**DECISION SUPPORT FOR BEST PRACTICES:
LESSONS LEARNED ON BRIDGING THE GAP
BETWEEN RESEARCH AND APPLIED PRACTICE**

Raimund L. Feldmann, Forrest Shull, and Michele A. Shaw

Today, everyone is looking for best practices for developing a system or for making the right choice in acquiring system components. If the right best practices are applied, they help to avoid common problems and improve quality, cost, or both. However, finding and selecting an appropriate best practice is not always an easy endeavor. In most cases such guidance, based on sound experience, is missing; often the best practice is too new, still under study, or the existing experiences do not fit the user's context. This article reports on a program that tries to bridge the gap between rigorous empirical research and practical needs for guiding practitioners in selecting appropriate best practices.

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**SENSE AND RESPOND: AN EMERGING
DoD CONCEPT FOR NATIONAL DEFENSE**

Russell A. Vacante

Sense and respond is a concept that is emerging from the context of the network-centric environment. The relative unfamiliarity of this concept within much of the defense community suggests that its meaning and necessity are not completely understood. To help make sense and respond less a catchphrase and more a well understood concept, the text that follows will address: what the term sense and respond means, why it is important to our national security, and its relationship and application to the logistics community. The goals of this article are to provide the reader with a fundamental understanding of the sense-and-respond concept and promote greater dialogue among a larger group of interested parties on this concept.

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APPLICATION OF STRUCTURED DECISION-MAKING TOOLS TO DEFENSE ACQUISITION

LCDR John R. Gensure, USN (Ret.)

The Defense Acquisition System is heavily dependent upon quality decision making. The application of structured decision-making tools to Defense acquisition problems can significantly assist the decision maker in the analysis of complex decisions, particularly those involving uncertainty, risk, and multiple objectives. Decision analysis and operations research are structured decision-making tools that can aid the decision maker in avoiding biases, documenting decision methodologies, and making group decisions. Overall, the systematic application of structured decision-making tools can significantly increase a decision maker's insight into the complex decisions that are characteristic of the Defense Acquisition System.

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THE CHALLENGES AND OPPORTUNITIES OF IMPLEMENTING HUMAN SYSTEMS INTEGRATION INTO THE NAVY ACQUISITION PROCESS

James A. Pharmer

Over the last decade, the Department of Defense has placed increased emphasis on including considerations of human capabilities and limitations into systems engineering and acquisition processes. The purpose of this article is to provide an overview of how the Navy is implementing Human Systems Integration (HSI), the process of incorporating considerations, characteristics, capabilities, and limitations of human operators and maintainers within acquisition decision making at a level commensurate with decisions regarding hardware and software. More specifically, this article will address some of the policy initiatives, organizational changes, and implementation challenges of incorporating HSI into the acquisition life cycle to insure better total system performance and lower total ownership cost.

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**APPLYING OFFICE LEADERSHIP SOLUTIONS TO MANAGEMENT
RECOMMENDATIONS IN SOLVING ACQUISITION PROBLEMS**

Martin Cain

Leadership is the process by which high-performance acquisition takes place. Influences on management as a result from inspections such as internal auditing can pull attention from long-term leadership goals. This article researched the nonquantifiable impacts from internal auditing and compared them to effective leadership principles. Conclusions indicated that management could make better use of audit recommendations by applying leadership to actions in solving problems and implementing change.

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FROM THE
EXECUTIVE EDITOR

PROBLEM SOLVING IN THE 21st CENTURY



Welcome to the *Defense Acquisition Review Journal* (ARJ) theme edition on “Problem Solving in the 21st Century.” Dramatic advances in technology and computing power make higher-order thinking and sound reasoning essential elements of problem solving in the modern era. These skills include the cognitive processes of analysis, comparison, inference and interpretation, evaluation, and synthesis applied to a wide range of domains and problem-solving contexts. However, the basic skills of leadership, personal interaction, collaboration, and teamwork continue to provide effective methods for reaching solutions.

On behalf of the Defense Acquisition University (DAU) Press, the *Defense ARJ* managing editor, and staff, I would like to personally thank the leadership of the DAU Southern Region, Huntsville, AL, for selecting the theme and sponsoring this edition of the journal. Professor David Eiband is also commended for his tireless efforts and tenacity while leading in the selection process and coordination of this issue between DAU South and DAU Headquarters, Fort Belvoir, VA.

Thus, the edition begins with an article entitled, “Problem Solving in Defense Contract Management Services: Collaboration and Teamwork—The Key to Successful Warfighter Contract Support,” by Lt Col (Sel) Gilberto Rosario, USAF; Joseph Vernon; William Kleiner; and Matthew Popham. In this article, the authors point out that while past management approaches to business interactions yielded less than optimal results, a new emphasis in collaboration and teamwork between the Rolls-Royce Corporation and the Defense Contract Management Agency (DCMA) quickly produced sizable benefits for both parties.

Eugene Gholz describes a business model that companies could apply to the development, production, and sale of avionics to the Department of Defense (DoD) in his article, “A Business Model for Defense Acquisition under the Modular Open Systems Approach.” This model uses a Modular Open Systems Approach (MOSA), which has been encouraged through acquisition reform initiatives and emphasizes a thorough understanding and application of core competencies, principal activities, cost structure, and an expected revenue stream to enable sufficient profits to remain in business in a competitive environment.

The article, “Decision Support for Best Practices: Lessons Learned on Bridging the Gap between Research and Applied Practice,” by Raimund L. Feldmann, Forrest Shull, and Michele A. Shaw, examines the process of selecting and implementing best practices. In some cases, a best practice may be only appropriate for a specific scenario or context, and in other cases, a best practice could fit a new or emerging system with evolving threats and tactics. In addition, the authors describe a program that tries to bridge the gap between rigorous empirical research and practical needs for guiding practitioners in selecting appropriate best practices.

Russell A. Vacante’s article, “Sense and Respond: An Emerging DoD Concept for National Defense,” explores the importance of a new concept emerging from the network-centric environment philosophy. This concept is relatively new within much of the defense community, and its true meaning and utility may not yet be completely understood. Dr. Vacante emphasizes why sense and respond is so important to national security in the 21st century and explains its relationship to the logistics community.

LCDR John R. Gensure, USN (Ret.), presents an overview showing how the use of decision analysis and operations research can significantly assist decision makers in the complex world of defense acquisition in his paper entitled, “Application of Structured Decision-Making Tools to Defense Acquisition.” These types of tools enable managers to trade off factors, such as uncertainty, risk, and multiple objectives and priorities to reach optimal decisions. Systematic application of structured decision-making tools can significantly increase a decision maker’s insight into the complex scenarios of defense acquisition.

The next article, “The Challenges and Opportunities of Implementing Human Systems Integration into the Navy Acquisition Process,” by James A. Pharmed, provides a look at how the Navy is implementing Human Systems Integration (HSI)—the process of incorporating considerations of human capabilities and limitations at a level commensurate with decisions regarding hardware and software. The author also addresses policy initiatives, organizational changes, and implementation challenges while incorporating HSI into the acquisition life cycle.

Last but not least, “Applying Office Leadership Solutions to Management Recommendations in Solving Acquisition Problems,” by Martin Cain, focuses on a study of leadership as a primary force allowing high-performance acquisition to materialize. This article examines influences on management resulting from inspections, such as internal auditing, and researched the nonquantifiable impacts while comparing them to effective leadership principles. Conclusions emphasize that appropriate leadership is always key in solving problems and implementing change.

I would like to encourage other organizations to sponsor editions of the Defense ARJ. If you have an idea for a theme, we want to hear about it. For more information on sponsoring an edition of the journal, please feel free to send inquiries to the managing editor, *Defense ARJ*, at DefenseARJ@dau.mil.

Dr. Paul Alfieri
Executive Editor, *Defense ARJ*

FEBRUARY 2007

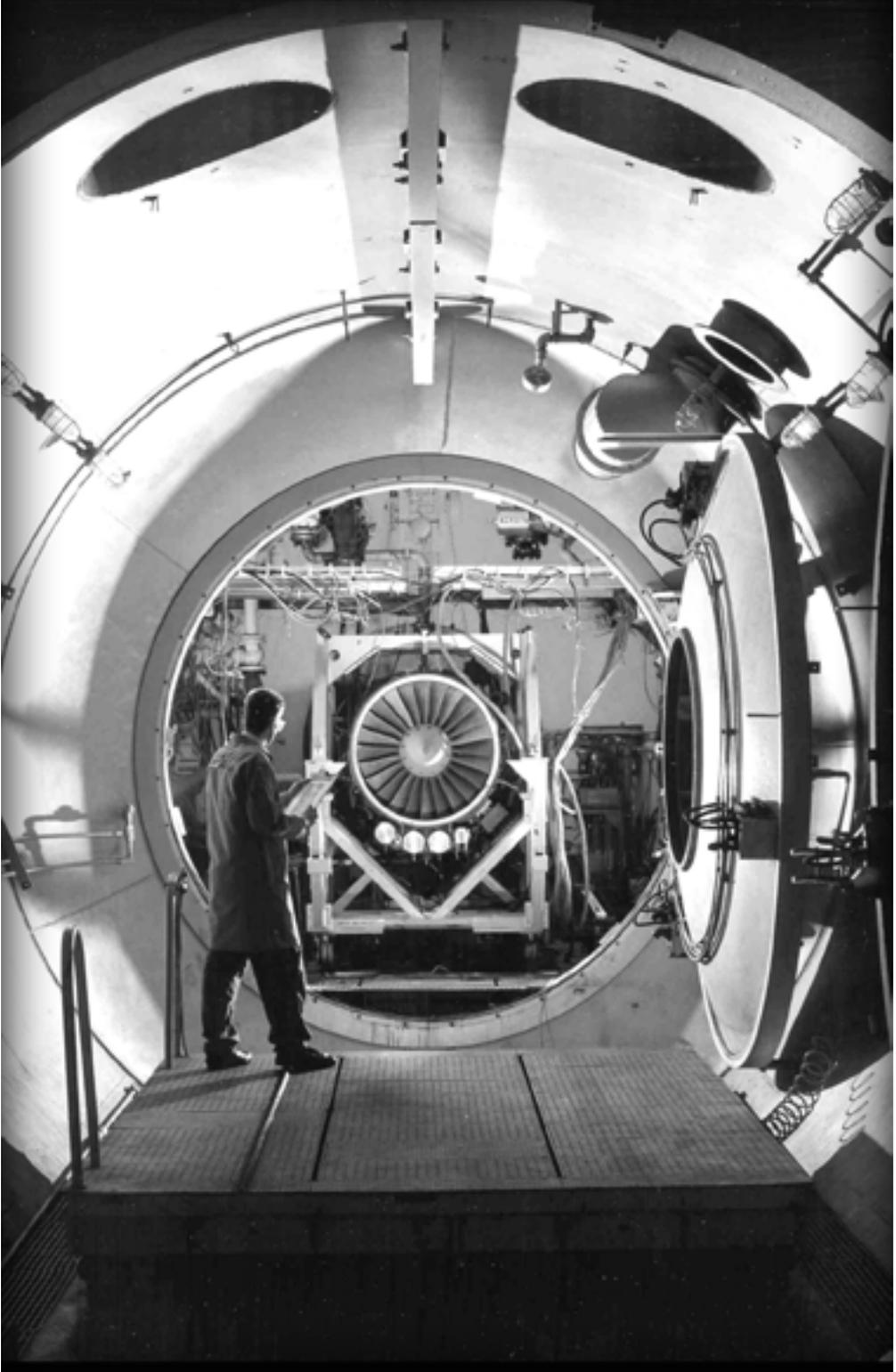


Photo courtesy of the Rolls-Royce Corporation

PROBLEM SOLVING: COLLABORATION AND TEAMWORK— THE KEY TO SUCCESSFUL WARFIGHTER CONTRACT SUPPORT

*Lt Col (Sel) Gilberto Rosario, USAF, Joseph Vernon,
William Kleiner, and Matthew Popham*

The Defense Contract Management Agency (DCMA) and the Rolls-Royce Corporation discovered that through close collaboration and teamwork, day-to-day business issues that previously required significant time and resources to be resolved instead quickly started to disappear or to require less effort to be resolved. This article discusses the underpinnings of a successful government and contractor collaboration through the discussion of DCMA's contract management services, the contractor's environment, technical challenges realized within manufacturing and business systems, followed by a look at problem solving approaches and philosophies, all of which led to significant improvements in both the quality and on-time delivery to the warfighters at a fair and reasonable price.

The Defense Contract Management Agency (DCMA) is a combat support organization within the Department of Defense (DoD) that provides worldwide contract management services to all branches of the U.S. Armed Forces as well as to other government agencies, such as the U.S. Department of Energy and National Aeronautics and Space Administration (NASA). In addition to DCMA's global offices, the Agency consists of men and women currently deployed overseas performing Contingency Contract Administration Services (CCAS). The DCMA's mission is to "provide customer-focused acquisition life cycle and combat support to ensure readiness, worldwide 24/7" (DCMA Vision, Mission, and Goals, n.d.). For

that reason, the people at DCMA strive to make certain that the warfighter receives the right product at the right time while paying the right price. This is accomplished through the effective integration of various disciplines, as practiced by administrative contracting officers (ACOs), contract administrators, price analysts, industrial specialists, quality assurance specialists, engineers, support program integrators, earned value management, property administrators, and management analysts. A key figure in this challenging effort is the ACO, who functions as the integration agent ensuring proper interpretation and execution of the contractual obligations between the contractor and the government. In this role, the ACO can effectively interact between the contractor and the government contract administration support team to ensure the warfighter's requirements are fully met and the delivery of products and services occurs within both cost and schedule at the highest possible level of quality. The DCMA Aircraft Propulsion Operations-Rolls-Royce is the cognizant DCMA office located in the contractor's facility in Indianapolis, Indiana.

ENVIRONMENT: CONTRACTOR MANUFACTURING FACILITIES

The Rolls-Royce Corporation in Indianapolis, Indiana, maintains 2.6 million square feet of manufacturing space and an additional 900 thousand square feet dedicated to research and development. The facility employs 4,300 workers and delivers approximately 2 engines and \$1 million in spares per day, and has 2,700 active machine tools, 7,000 active part numbers, and \$1.5 billion in annual sales.



FIGURE 1.
ROLLS-ROYCE DEFENSE NORTH AMERICA, INDIANAPOLIS, INDIANA

Furthermore, Rolls-Royce has invested over \$200 million in capital improvements since purchasing the facility in 1995.

Rolls-Royce Corporation's primary product, gas turbine engines, supports civil, military, energy, and marine applications worldwide. Major customers include the U.S. Navy, Army, Air Force, Marines, Coast Guard, Lockheed Martin, Northrop Grumman, Bell, Boeing, and Embraer. The facility, formerly Allison Engine Company, has a proud heritage of supporting the warfighter. Since its inception in 1915, the company has produced state-of-the-art engines that embody cutting-edge technology. The facility has produced over 110,000 engines. From the venerable T56 turboprop, used on more than 5000 C-130s worldwide, to the latest AE1107 Liberty engine powering the V-22 Osprey and the AE3007 turboprop utilized on the RQ-4A Global Hawk, the tradition continues. The company's performance has been validated by the presentation of seven Collier Trophies for innovation since 1987.

TECHNICAL CHALLENGES

MANUFACTURING AND ON-TIME DELIVERY

The timely delivery of quality products is a primary goal of the procurement activity, DCMA, the contractor, and ultimately, of great significance to the warfighter. The importance of this goal is reflected in the DCMA performance metrics, which were adopted by Rolls-Royce senior management. In order to achieve this goal, the manufacturer must employ adequate program management, master production scheduling, and enterprise resource planning. In today's commercial environment, specifications normally originate from the Original Equipment Manufacturer (OEM) in response to performance requirements from the government. To achieve this, required performance tolerances on specifications are even tighter with little or no variance. Additionally, in today's post-9/11 environment of multiple military deployments, increased demands of products and services, raw material shortages, and increased research and development activities, the ability to deliver a flawless aircraft engine or component when the government wants is an ever increasing challenge.

FINANCIALLY VIABLE BUSINESS SYSTEMS

The contractor's business and financial health is of major concern to the government, as a higher degree of financial risk can mean increased costs to the government. This is especially true with large contractors, upon whom the government relies to provide major defense systems and subsystems. The assessment of this financial risk to the government is accomplished through the application of business systems¹ and Cost Accounting Standards (CAS)² as established by public law. Adequate Business Systems and CAS compliance means smoother and less complicated proposals and pre-awards through a greater reliance on the contractor's ability to track, estimate, and forecast costs, which results in lower risk to the government and earlier contract award. Large defense contractors, such as Rolls-Royce, endeavor to maintain "adequate" business systems and CAS compliance

even though adequacy can be somewhat subjective. Although business systems are highly regulated, the determination of an adequate business system often rests on the application of the government's interpretation of the regulatory and statutory language against the contractor's current policies and procedures. Keeping a company's business systems adequate is a daunting task but the lack of adequate business systems can lead to the loss of new government contracts and subcontracts as well as possible withholds and decrements consequently creating cash flow and resource issues for both the contractor and the government.

PROBLEM SOLVING APPROACHES

MANUFACTURING APPROACH

Approximately five years ago, the leadership of Rolls-Royce and the local DCMA realized that a different approach was needed to increase the timely delivery of quality engines and components. Out of this need was born the integrated team approach, which has transformed the way the government and the contractor do business.

The first team assembled was chartered to identify and eliminate the causes of late delivery. In contrast to past practices, both DCMA and Rolls-Royce representatives were in the room together to discuss specific issues and solutions. Each step of the process was mapped, resulting in a combined understanding of the factors driving delivery excellence throughout the entire supply chain including delivery to the end user. Tracking performance was accomplished by the Team's agreement to use the DCMA On-Time Delivery 2002 proposed Performance Goal of 70 percent as a baseline. Team members shared timely and pertinent information and discussed solutions resulting in an atmosphere of understanding and trust focused on eliminating obstacles. This joint collaboration resulted in the Team setting a higher local on-time delivery goal of 90 percent for 2006, of which Rolls-Royce has consistently achieved a level of on-time delivery of 95 percent or better. More importantly, the process also took the surprise factor out of the equation. If a part was going to be late, required rescheduling, or had other constraints, both parties knew about it well in advance. This information could then be provided to the procurement activities so that mitigating actions could take place as required.

This approach garnered wide recognition. First, the facility was awarded for Outstanding Supply Chain Management by the U.S. Air Force Material Command in 2001. It was also awarded the DCMA Herbert W. Homer Team Performance Award—Delivery Management Integrated Product Team in 2002, and the Rolls-Royce Chief Executive Quality Award in 2003.

Since the first integrated team, many others have been chartered with similar results such as quality assurance, in which Rolls-Royce and DCMA share audit schedules, findings, trends, and corrective and preventative action programs. The DCMA now accompanies Rolls-Royce during each of their ISO 9001 audits and certifications. They also attend outbriefs and participate as corrective and preventative actions are assembled. Other teams perform Material Review Boards (MRBs), as

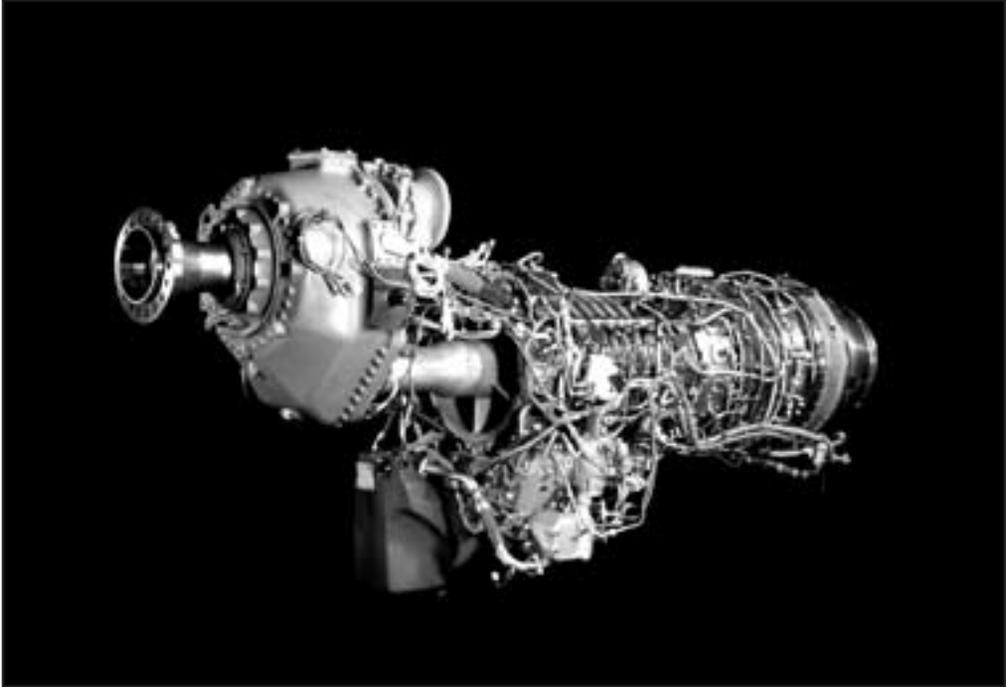


FIGURE 2. ROLLS-ROYCE AE3007 GAS TURBINE ENGINE

well as reviews of vital statistics, scrap, compliance, process initiatives, and field feedback. The DCMA keeps Rolls-Royce informed about field reports so there is a real—time review and both organizations stay proactive in dealing with any issue real or potential that may impact the end user.

This integration has promoted the tenants of open communication, trust, and continuous improvement, all of which are vital to the success of our combined mission to provide the best quality engines and commodities possible.

BUSINESS SYSTEMS SOLUTIONS

The purchase of the Indianapolis facilities by Rolls-Royce in 1995 created major changes in the company's business systems and complex accounting practices, which continue to evolve. Realizing that sound business systems and accounting practices are crucial elements in maintaining and securing government contracts, the government and Rolls-Royce began in 2004 to take a proactive approach to ensure the company has strong internal business and financial controls by implementing a biweekly Integrated Process Team (IPT). Participants in this IPT include various members of Finance and Compliance on the part of Rolls-Royce Corporation. Government participants include the DCMA ACO and the Defense Contract Audit Agency (DCAA). Meetings include the review of all open issues and airing concerns and observations. If system improvements are warranted, the process begins immediately rather than awaiting the issuance of a DCAA draft audit report. The IPT has experienced several instances where early identification of issues and

immediate evidence of contractor corrective actions resolved the issue and negated the need for further DCAA involvement. Moreover, due to the open deliberations that occur within the process, the ACO is in a greater position to make an informed determination that is beneficial to both the government and the contractor all while satisfying regulatory and statutory requirements.

An additional example of open communication and transparency of company processes include the active participation in company system conversions. For example, when the company implemented a Plant Structures project to replace the Billing and Material Management Accounting Systems (MMAS) on the Systems Applications and Products in Data Processing (SAP), DCMA and DCAA were invited to all training sessions and steering committee meetings. The government was also provided an “issues log” enabling them to track the resolution of system implementation issues.

In addition to IPT meetings, the company’s Government Compliance Manager and the DCAA Supervisor meet regularly to review all business system status reports. This meeting is directly related to the IPT process and, again, allows for early identification of potential issues, rather than addressing the issues within an audit report. The DCAA’s timely reviews, once corrective actions have been taken, represent another necessary aspect both the company and DCMA rely upon.

COLLABORATION AND TEAMWORK

PROBLEM-SOLVING PHILOSOPHY

Up to the moment when DCMA and Rolls-Royce decided to join efforts to address and solve issues in a collaborative fashion, both parties basically performed issues analysis and resolution independently of each other. This approach was inefficient in that a lot of time and effort went into solving issues in isolation; data and information were exchanged in separate analytical environments. This method had the disadvantage of requiring multiple exchanges of data and information without the benefit of having the same forum or the right individuals with the knowledge and expertise to provide answers and clarification in a real-time basis. Therefore, solving issues was a lengthy and time-consuming endeavor not sufficiently agile to resolve issues.

Once both parties decided to join efforts and work collaboratively in the early identification and resolution of issues, efficiencies were realized immediately. Both teams as well as the warfighting customers started to see the tangible benefits of this approach though increased on-time delivery, a reduction of quality issues in the field, and a better understanding of the contractor’s business and financial health. What actually existed after the new collaboration efforts began was a collectively shared sense of purpose augmented by the empowerment given to both DCMA and Rolls-Royce teams by their senior management, thus enabling the teams to tackle the issues and allocate resources to solve them.

THE DCMA AND ROLLS-ROYCE EXPERIENCE

Gigantic strides have been made in the overall relationship between DCMA and Rolls-Royce, primarily due to the realization that (a) both are working toward a common goal of providing the best product to the end user at the right time and for the right price, and (b) that in today's environment of declining resources, it is better to offensively pool assets towards common goals rather than to use assets defensively against each other. Such a relationship must be built on trust and an understanding that both the government and the contractor share an immense obligation and responsibility to provide the best quality product to the end user when and where it is needed. However, trust and understanding play an even greater role where the goals of the government and the contractor differ, such as disagreements about price, delivery schedules, or policies, such as the Berry Amendment Specialty Metals Clause,³ Critical Safety Items (CSI),⁴ and Business System Status. In such situations, the need for open and honest communication is imperative to keep product moving, the contractor paid, and the opportunity granted for new business and corporate growth. Hidden agendas and unilateral posturing lead only to an environment of suspicion and lack of cooperation whereby everyone, especially the end user, loses through the re-alignment of resources in a defensive posture.

Most importantly, both government and corporate senior management have given their people the authority to exercise prudent business judgment in the resolution of issues as well as binding the parties in bilateral agreements. Conversely, along with such authority comes accountability as well as the realization of the consequences of honoring agreements and commitments. Thus, the framework of government



FIGURE 3. ROLLS-ROYCE 2100D2 TURBO PROP ENGINE

and corporate collaboration is very similar for both the manufacturing and business systems environments. The lines of communications have been established through senior management sanctioned IPTs, giving the individual teams the authority and accountability to work out complex issues and implement prudent business corrective actions. This in turn leads to the ultimate success and satisfaction of all interested parties, while ensuring the mission is accomplished.

There are several areas in which both the government and the contractor must ensure that the right conditions exist if any collaborative effort is to have a fertile ground to grow. These areas include:

1. **People:** It is management's responsibility to ensure that the right human capital is employed. Both entities must choose to allocate individuals who have the proper background and right level of experience to function effectively in this teaming effort.
2. **Framework:** Both parties must agree to a common structure in which the collaborative relationship will exist. This framework spells out the type of teams needed, who is needed on the team, the scope and authority of the team, and the team's oversight. In this case, the Manufacturing Team is made up of both Rolls-

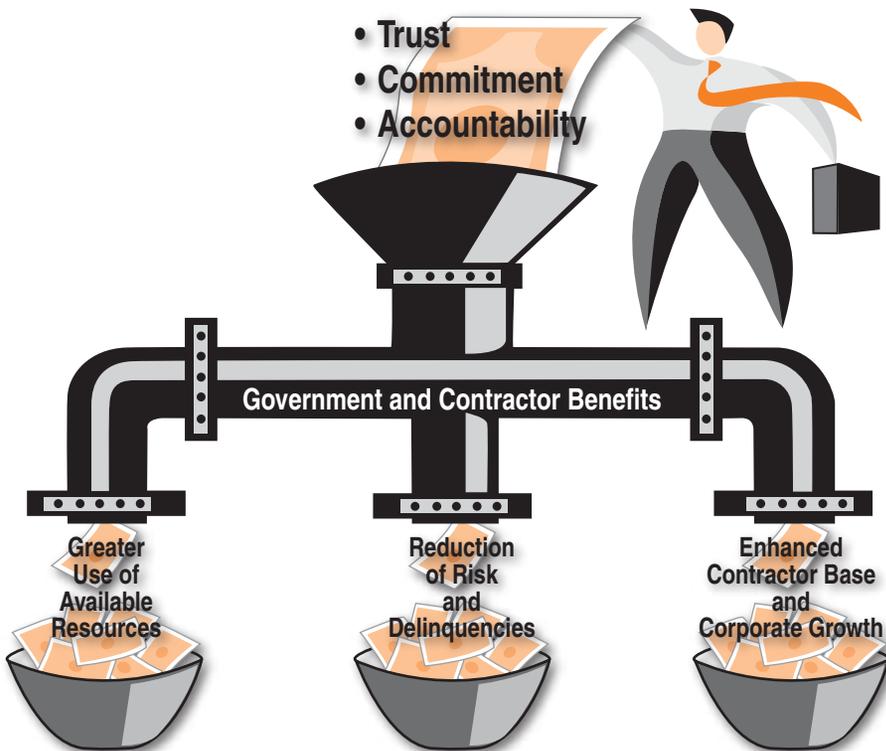


FIGURE 4. BENEFITS OF COLLABORATION AND TEAMWORK

Royce and DCMA Quality Assurance representatives while the Business and Financial Team is represented by contract and accounting members from Rolls-Royce, DCMA, and DCAA.

3. **Rules and Protocols:** These provide for a disciplined and structured approach to solving issues. Before both parties decide to join efforts as one integrated team, each team has its own set of rules and protocols to identify, work, and solve problems. This approach has often resulted in a cognitive disagreement between the teams, thus generating a psychological state of conflict. Now, both the manufacturing and business teams are aware and follow required rules and protocols, so that each team may focus on the specific issue rather than the process.
4. **Trust:** One of the pillars of success to the DCMA and Rolls-Royce collaboration experience is trust. Past interactions between the government and Rolls-Royce were plagued by both parties arriving at conclusions within a separate analytical environment. This situation proved fertile ground for distrust between the parties, because neither one had an opportunity to openly discuss specific details or particular circumstances associated with the problem. By having both teams in the same room at the same time with the right individuals, confidence and reliance on each member was established. This was reinforced through the open and honest sharing of information and the commitment of team members to work through complex issues with a common goal resulting in a heightened degree of trust and understanding.
5. **Senior Leadership Support:** Once a decision was made to establish the IPT, both teams' senior management remained engaged and closely involved in the IPT implementation and execution. Human resources were exclusively allocated and dedicated to the IPT, and team members are fully empowered to make decisions and commitments to see that issues are completely solved. This support, combined with the increased level of trust, is pivotal to the successful DCMA/Rolls-Royce teaming effort.

CONCLUSIONS

There are several characteristics that can be identified as key to the success that DCMA and Rolls-Royce have experienced through their journey to better collaboration and teamwork in support of the warfighter. Whereas in the past both teams were individually less efficient at solving issues, the new collaborative approach yields quantifiable benefits for everyone (e.g., timely delivery and financial stability). First and foremost, there must be full commitment and sponsorship from each organization's senior leadership. It is absolutely critical that each organization identify and assign the right human talent and resources. Second, there must be a clear set of rules and protocols for the team to follow. Up-front definition of

procedures, roles, and responsibilities ensures the efficiency of every team member through concentration on the issue rather than the process. This helps the team stay clear of misunderstandings and potential disappointments that can corrode the synergy, cohesiveness, and trust that takes a lot of time and effort to develop. Finally, it is absolutely necessary that the team have the time, resources, and authority needed to execute developed plans and strategies.

In conclusion, the DCMA and Rolls-Royce experience demonstrates that, when the government and contractor come together in collaboration for the positive resolution of issues, the end result is a win-win situation.

In conclusion, the DCMA and Rolls-Royce experience demonstrates that, when the government and contractor come together in collaboration for the positive resolution of issues, the end result is a win-win situation. The warfighters are provided with what they need, when they need it. The government can ensure proper expenditure of taxpayer dollars as well as a secure vendor base, and the contractor can enjoy the opportunity for corporate growth. This example of successful collaboration and teamwork can be used as the basis to develop similar working relationships within other components of DoD, particularly in the acquisition community.



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ENDNOTES

1. There are currently ten primary business systems. These include accounting, billing, budget and planning, compensation, estimating, indirect and other direct cost (ODC) internal controls, general Information Technology (IT) controls, labor, purchasing, and material management, which are audited by the government on a recurring cycle in accordance with the Defense Contract Audit Agency (DCAA) Internal Controls Audit Planning System (ICAPS).
2. Rolls-Royce is considered a “Full Coverage” contractor as described in FAR 9903.201-2 and is therefore required by Public Law 100-679 (41 U.S.C. 422) to comply with all Cost Accounting Standards specified in Part 9904.
3. The Berry Amendment, as stated in 10 U.S.C. 2533a, originated in 1941 and was established to address concerns over the procurement of domestic materials for use in U.S. military items. The Specialty Metals Clause, as stated in DFARS 252.225-7014, was added to the Berry Amendment in 1972 and addresses the use of such specialty metals as titanium, zirconium, and steel alloys in U.S. military commodities. Recent events between metal producers and Original Equipment Manufacturers (OEMs), especially the aeronautical industry, have resurfaced this statutory requirement, as well as interim governmental guidance pursuant to acceptance, exceptions, and monetary withholds based on the value of nonconforming parts.
4. Critical Safety Items (CSIs), as described in DFARS 209.270, are parts, assemblies, or equipment for aircraft or aviation systems of which catastrophic or critical failure could result in (a) loss of or serious damage to aircraft or weapon system, (b) unacceptable risk of personal injury or loss of life, or (c) uncommanded engine shutdown that jeopardizes safety. The Joint Aeronautical Logistics Commanders (JALC) have implemented specific directives pursuant to the National Defense Authorization Act (Public Law 108-136), of which Section 802 requires the Secretary of Defense to prescribe a policy for the quality assurance of aviation CSIs. Therefore, DCMA is tasked with the central role of evaluating the CSI characteristics or features that have been identified by the respective Service Engineering Support Activity (ESA). For any part that has been identified by ESA as a CSI with critical characteristics, the Product Assurance Specialist will perform surveillance activities using a Quality Release Level that has been specified within the agency’s Product Assurance Instructions and Guidance documents. If a part has been identified as a CSI but critical characteristics or features have not been identified by the ESA, DCMA is responsible for evaluating those processes that are directly related in the manufacture of the CSI and have been deemed important by the ESA.



Image designed by TSgt James Smith, USAF, and Michael King

A BUSINESS MODEL FOR DEFENSE ACQUISITION UNDER THE MODULAR OPEN SYSTEMS APPROACH

Eugene Gholz

This article briefly describes a business model that companies may apply to develop, produce, and sell avionics to the Department of Defense under a Modular Open Systems Approach (MOSA). Recent acquisition reforms have encouraged the use of MOSA, and the defense industry will need to adapt to the new style of acquisition. A business model summarizes the way a firm earns profits sufficient to remain in business: it describes core competencies, principal activities, cost structure, and expected revenue stream. The model proposed here suggests that firms can succeed under the new framework, but that MOSA entails some drawbacks for both industry and the government that may limit its applicability to a relatively small subset of programs.

Over the past several years, the Department of Defense (DoD), the military services, and the defense industry have sponsored a good deal of research about the technical aspects of a Modular Open Systems Approach (MOSA) to the acquisition of avionics.¹ The results have shown that while some technical hurdles still remain, business issues may be bigger barriers than technical ones to the implementation of MOSA.² Advocates of MOSA must show that the new approach will solve some problems for the defense industry as well as for its military customers and that the companies can be at least as profitable under MOSA as under traditional acquisition strategies. Firms in the defense industry are relatively comfortable with their traditional business model, and they require business analysis to give them an incentive to aggressively pursue change. They are generally quite ready to cooperate

with their customers' initiatives—in fact, responsiveness to the unique military customer is a hallmark of successful defense companies (Gholz & Sapolsky, 1999-2000)—but the customers need to put their request for such cooperation in the business language of company decision makers.

A business model summarizes the way a firm earns profits sufficient to remain in business: it describes core competencies, principal activities, cost structure, and expected revenue stream.

This article briefly describes a business model that companies may apply to develop, produce, and sell avionics to the DoD under MOSA. A business model summarizes the way a firm earns profits sufficient to remain in business: it describes core competencies, principal activities, cost structure, and expected revenue stream. Defense firms organized for “business as usual” will find a transition to MOSA difficult, and they may prefer to create new MOSA-oriented divisions rather than attempting to transform the culture of established organizations (Christensen & Raynor, 2003). Even if the military adopts MOSA for many acquisition projects, the traditional approach will remain in force for many high-value projects to which MOSA is not well suited; defense firms should maintain their existing structures to pursue non-MOSA acquisitions. But defense firms also stand a reasonable chance to do profitable business on some avionics projects under a MOSA business model. In a capitalist economy, a reasonable chance of profitable business, and not a guarantee, is exactly what investors and CEOs hope to find.

THE TRADITIONAL DEFENSE INDUSTRY MODEL

During the post-World War II era, the American defense industry developed a specialized business model, especially for prime contractors (Gansler, 1995; McNaugher, 1989). Generally speaking, today's defense companies closely follow directives from their military customers, developing customized products with attributes specified in advance by the buyer. The buyer pays the development costs up front or in stages during the development process. Because defense firms primarily invest the customer's money rather than their own in research and development, the firms have a limited role in choosing the technological trajectory that they will pursue (Dombrowski & Gholz, 2006). Consequently, they have relatively less skill in technology management than companies in other industries that emphasize innovation to a comparable extent. The most responsive defense companies tend to

be the most successful: executives and managers constantly reassure their customers that the customers' interests are the firm's top priority and adapt the firm's business processes to remain relatively efficient while following complex and intrusive acquisition regulations.

In the traditional defense business model, firms (especially prime contractors) are rewarded with a relatively stable income stream. Their close relationship to the military customer gives them a relatively low level of risk, comparable to the steady, low-risk business of a regulated public utility (Gholz & Sapolsky, 1999–2000).

MOSA AND ITS GOALS

As the American military increasingly relies on information technology in its new weapon and support systems, the traditional business model seems less appropriate than it used to. Advocates have proposed MOSA for avionics acquisition to adapt to the military's plans for network-centric warfare, to take advantage of technological opportunities that have developed in the commercial information technology business, and to improve the sustainability of military equipment as the product cycle for avionics has raced ahead of the long life cycle of the military's platforms. They also hope that MOSA can exploit the advantages of competition to control the soaring costs of systems acquisition.

Under its current business model, the defense industry tends to customize products on a platform-by-platform basis, but with transformation, each firm's proprietary technical solutions need to interface with other firms' proprietary products.

The shift to network-centric warfare is one of the major drivers for MOSA. The American military expects to use the next generation of equipment to share information across the battlespace more than ever before. Under its current business model, the defense industry tends to customize products on a platform-by-platform basis, but with transformation, each firm's proprietary technical solutions need to interface with other firms' proprietary products. Even if firms do not share the technologies that underlie their products' internal performance and only the interface designs are widely disseminated, defense systems as a whole will become less proprietary. This trend emphasizes the "open systems" part of MOSA: open systems are "integrated from elements provided by multiple sources" based on

“nonproprietary interface standards” (Committee on Aging Avionics in Military Aircraft, 2001, pp. 32–33). At the technical level, MOSA requires decisions about what those interface standards should be. Meanwhile, MOSA calls for defense industry design teams to focus on learning open interface standards and to contribute their expertise to the process of choosing and updating the standards.

The increasing military interest in information technology (IT) has also naturally drawn attention to the commercial IT industry. Since the 1990s, many people have observed that commercial IT tends to be more advanced than military IT. Commercial businesses also offer nearly continuous innovation to their customers (Alic, Branscomb, & Brooks, 1992), enabled by modularity of commercial products. Commercial customers can replace parts of their systems when new component technologies become available rather than paying to replace the entire system. Internal changes can increase a module’s capabilities or simply reduce the cost of production or operation of a module at the same level of performance (Committee on Aging Avionics in Military Aircraft, 2001).

The increasing military interest in information technology (IT) has also naturally drawn attention to the commercial IT industry.

In the new language of defense acquisition, modular design facilitates spiral development. Because modules can be replaced one by one and can be taken from existing systems and combined in new ways to produce new systems, the customer need not define all of the performance requirements for a system in advance. Instead, the customer can experiment with an initial version to reveal which modules most tightly constrain overall system performance. That experience will then allow the customer to define reasonable performance requirements for the next iteration of equipment and to focus resources in the next development spiral on improving key modules without redesigning the entire system.

In the same way, modular design also facilitates technology refresh, reducing the need to maintain obsolete parts in legacy systems. If a system is designed to be modular, obsolete parts can be thrown away and replaced with newer, cheaper, more capable parts. As long as the new module has the same external compatibility, it will not matter whether the internal components are the same as the old ones. The military will no longer need to stockpile replacement parts or maintain production lines that freeze technology at a particular point in time. Recognizing the fast rate of improvement in computer hardware and software and other electronics, many modular components can be designed with the assumption that they likely will be replaced through a technology insertion program. This design change will have the

added benefit of eliminating the need for expensive efforts to guarantee performance through years of use, because many parts will be “disposable” after relatively short life spans.

The combination of modularity with open systems may gain additional benefits of competition, spurring innovation, and controlling costs. Under the traditional defense acquisition approach, the customer is often locked in to buying parts from a sole source (the original producer). Some of the high cost of maintenance—probably a substantial fraction—is driven by the real overhead cost of maintaining inventories and keeping old production lines open. But many politicians, military leaders, and analysts fear that the cost is driven up a significant additional margin by the reliance on a monopoly supplier (Kovacic, 1999). Even though government auditors try hard to monitor actual costs, have tremendous access to the firm’s cost data, and strive to avoid paying “too much,” the lack of competition once a supplier is guaranteed a long-term market, especially for sales of replacement parts, makes the buyer vulnerable. Whether or not defense firms truly exploit their customers, American political and economic leaders distrust monopolies. The potential to eliminate monopolistic spare parts sales is a significant symbolic benefit of MOSA.

INTUITIVE SUMMARY OF THE BUSINESS MODEL

The MOSA redraws the division of labor between the government and industry in military systems development: industry will lead the relationship to a greater extent than in the traditional model. Instead of announcing detailed performance requirements for major systems acquisitions or upgrades, under MOSA the customer will only publish “roadmaps,” general descriptions that link the performance characteristics of new systems to the military’s evolving strategy and doctrine. Firms will create the detailed specifications and develop systems and modules that might interest the customer.

Companies will be able to propose improvements to modules or systems whenever they have a new product ready, developed on the companies’ preferred schedule—influenced, of course, by contacts with the military buyers. This company-led proposal process will not work for platforms or major avionics systems that Congress must fund on a line item basis, but it will be easier to implement for smaller systems and system components. The MOSA will be easiest in the maintenance and upgrade budgets, which rarely attract the attention of political leaders and already are supported through a process that delegates more discretion to program managers.

To maximize the advantage of MOSA for technology insertion and spiral development, the military will buy small batches of parts or systems. From time to time—perhaps on a regular schedule, perhaps when installed equipment breaks, or perhaps in response to unsolicited offers from defense firms—companies will be able to bid on a batch of sales. For each bid, the companies will have to provide a complete description of the performance characteristics of their products, a unit price, and a number of units for which that price will be valid. Firms will have the option to offer the same equipment that they offered in the previous iteration of competition

(at the same price or a new one), or they may offer a new product that incorporates additional technological progress. The customer might purchase the new batch from the incumbent supplier, or the customer may buy the new batch from one of the incumbent's competitors. The only advantage that the incumbent will enjoy in the competition would come from whatever benefit it had gained from learning-by-doing or economies of scale on production of the previous batch.

The government may ask for minor modifications of the product as part of the contracting process, but the more that those modifications are requested, the less the customer will be able to benefit from MOSA. Ultimately, if the customer requires too many modifications, it should apply the traditional acquisition model rather than the MOSA for the project in question.

PRIME CONTRACTOR CORE COMPETENCIES

The MOSA will require leading avionics companies to have two core competencies: technology management and portfolio management. Firms will still need to nurture skills in product design and manufacturing, just as they have under the traditional defense business model, but their current core competency in responding to intrusive government oversight and regulation will fade in importance.

Firms will use their core competency in technology management to decide how much to invest in research and development (R&D) and how much to charge per unit, given their products' performance specifications. This skill set is not entirely unfamiliar, as defense firms already project cost and performance when they make paper proposals early in competitive projects. But under MOSA, the firms will have substantially more discretion and will face significantly more complex technology management problems.

Most important, under MOSA the defense industry will choose what product improvements to offer and when those new products should be developed. Under the current system, warfighters sometimes suggest unrealistic hopes for new technology, because their expertise tends to emphasize the military arts rather than science and technology. The balance of emphasis in acquisition planning has especially shifted in favor of military rather than technical factors in recent years, as Combatant Commanders have gained a more prominent role in the process. This customer influence often drives the pace and direction of investment in ways that will not yield the greatest marginal research benefit, increasing R&D costs. Buyers also change their minds about what they want, leading to poorly planned investment programs or to the "hurry up and wait" syndrome that can sometimes plague systems development (McNaugher, 1989). Under MOSA, by contrast, the firms will decide on the trajectory of technological change that they should invest in, giving more influence to the "natural" direction in which technological improvements are available.

Firms should be more sensitive to the financial costs of lurches in their research program. Their decisions will not be driven purely by scientific estimates of which technical problems are most readily solved, because company executives are driven by the profit motive and because they will still have to consider what technological

improvements they think that their customers will want to buy. Prime contractors will also still consider their customer's social goals in their analyses of alternatives.³ But ideally, defense firms, which often employ former warfighters in their business development departments, will be in a better position than the military customer to understand simultaneously both the technical and warfighting influences on weapons development. As a result, the MOSA business model should increase the technical payoff and reduce the cost of R&D investment.

For the defense industry, the increased control of R&D investment comes at a price. First, the military customer will not always be interested in the technological improvements that the defense industry develops and offers. Firms will do their best to understand the military's needs, and under MOSA the military will work with industry to develop roadmaps that identify desirable product improvements. But forward-looking roadmaps will always imperfectly predict warfighters' needs and political leaders' budget priorities, so the customer may decline any particular product-price offer that a firm makes.

Second, because the companies gain control of investment decisions under MOSA, they will have to put their own money on the line. At least in the idealized MOSA business model, the companies will offer off-the-shelf products to the buyer—that is, products that they have developed on their own prior to offering them for sale.⁴ Development cost will be figured into the price at which the new product is offered for sale, as it is in commercial markets. The buyer will bear little technological risk, because the basic performance characteristics of the already developed device will be well understood at the time of the sale; the remaining uncertainty will focus on how the warfighter will actually use the device. In essence, the MOSA model gives companies control over their investment decisions, allowing them to advance their technological core competencies, but it increases the technological and market risk that they bear.

To face the increase in risk that comes with the MOSA business model, firms will need to increase their financial competency to manage a portfolio of technology.

To face the increase in risk that comes with the MOSA business model, firms will need to increase their financial competency to manage a portfolio of technology. Firms should expect to lose most of the frequent competitions that they enter. These losses, though, will not hurt too much because each competition only offers the opportunity to sell a small batch of products to the military. Finance specialists in the defense industry will try to amortize the cost of R&D investment in *all* of the firm's new technologies into the prices bid on the competitions that the firm ends up

winning. The winning bids must pay for the successful product developments, the dead-end research projects, and the products that for whatever reason the customer has chosen not to buy. Because the customer will only buy a small batch at a time, the suppliers will not be able to earn a return on all of their investment on any individual sale. Instead, they will have to incorporate into their pricing strategies the probability that they will also win the follow-on contract. The pricing strategy and portfolio management decisions that MOSA asks of the defense industry are quite complex.

Through a combination of financial instruments, good market research, and sound competitive intelligence, defense firms under the MOSA business model should be able to bear the risk and earn a profit. When the current defense industry business model evolved during the Cold War, these techniques were less sophisticated than they are today. Today's firms stand a much better chance of succeeding at the complex business strategy decisions than they would have decades ago.

PRIME CONTRACTOR TASKS

Prime contractors' primary business activities will include routine collaboration with the customer on roadmapping the trajectory of technology, new product development that incorporates as many standardized modules as possible, and bidding on a plethora of small contracts to spread technology and market risk over a broad portfolio.

Technology roadmaps are essential to MOSA, because firms need a simple way to understand what their customers want from innovation. If firms are to choose how to invest their own R&D money, they will need a reasonable expectation that their customers will buy the products that result from any laboratory successes. Roadmaps provide broad guidelines and set headline goals but do not set particular investment priorities or product specifications. They draw on the military's operational experience, simulations that try to model the future strategic and tactical environment, and technical advice from military laboratories and defense contractors.

In the past, firms' principal contribution to their customers' technology planning was informal. Firms hired retired military officers who could interface easily with their active duty counterparts. Today, the firms' role in roadmapping is already expanding and becoming more formal. Some contractors have built sophisticated computer simulation systems that they use for strategic planning (and marketing). Under MOSA, a sale by a prime contractor will include a computer model of the product's behavioral characteristics, a model that can be plugged into future simulations and thereby contribute to future roadmaps. Some program offices (e.g., the Army's Future Combat Systems) have already used the contractors' simulation systems to better evaluate alternative project definitions and investment plans. This collaborative process will become routine under MOSA. Neither the customers nor the suppliers will be able to create sensible roadmaps on their own; collaboration on modeling and simulation will be a key task.

Prime contractors already advertise their main activity as systems integration rather than manufacturing, and MOSA will reinforce the importance of systems

integration (Gholz, 2003). In fact, the intellectual emphasis of the modular open system approach suggests that prime contractors should develop their products by incorporating as many already-developed component modules as they can, given technical constraints. Using such off-the-shelf contributions from Tier 2 suppliers will help reduce each prime’s up-front investment in in-house R&D and tooling, and the incorporation of such off-the-shelf modules will also reduce total system cost by allowing the subcontractors to plan to spread development costs for their modules across several final product lines. Through this process, the primes’ key proprietary knowledge will increasingly consist of their design team philosophies and their trade secret ways of drawing together subcontractors’ modules into optimally designed systems (Drezner, et al., 1992).

Prime contractors will also be responsible for partitioning the functionality of systems into modules. If a system is a set of “black box” modules that work together, someone has to decide what functions belong in each black box, what processing has to be accomplished internally by modules and what tasks can be shared within a central processing unit, and when functionality that had previously been accomplished by multiple modules can be better accomplished in the next iteration by a single, integrated box. Under MOSA, prime contractors will make those decisions. However, this systems integration task will require especially close collaboration

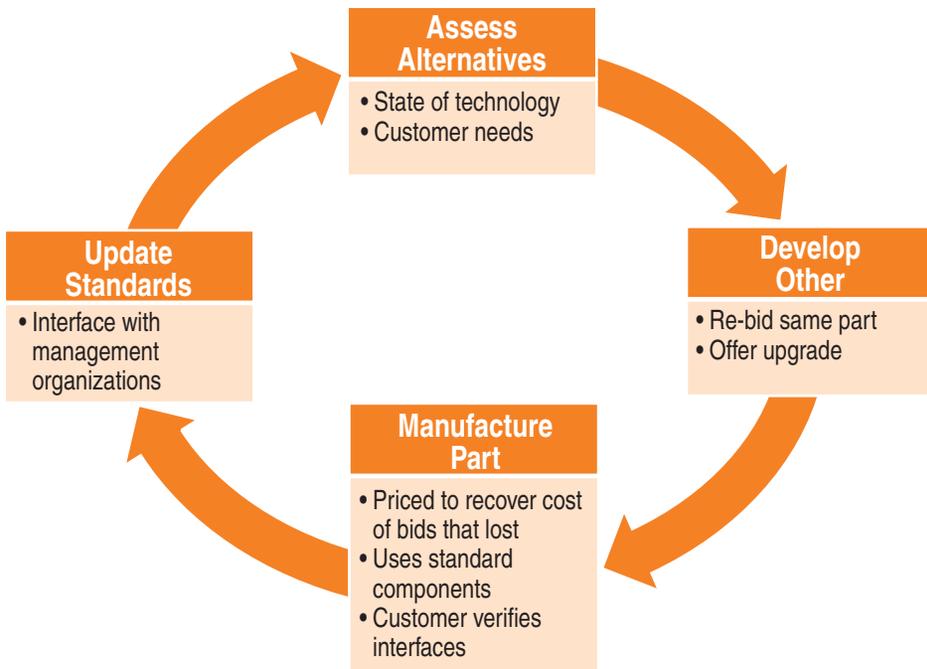


FIGURE 1. SUMMARY OF FIRMS’ ACTIVITIES UNDER THE MOSA BUSINESS MODEL

between the prime contractors and their customers, because changing the boundaries of modules will complicate the customers' maintenance and upgrade plans; modules will no longer be as interchangeable. As a result, MOSA will emphasize the interface between primes and their military customers.

Finally, to supply a given number of systems, prime contractors will make more separate offers to their customers than they do under the traditional acquisition approach. Each successful bid will win a smaller batch of production, meaning that a string of successes would be required to yield the same production run as a single win would enable under the traditional system. Furthermore, because MOSA facilitates competition and each individual firm should expect to lose a higher proportion of the competitions that it enters, prime contractors will each need to bid on a broader array of systems to maintain their workload.⁵ Bidding will have to become a more routine business practice, and perhaps well-defined interfaces and modular product designs will allow prime contractors to simplify the descriptions of what they are trying to sell to their customers. Moreover, if only a few modules of a system are changed from one generation to the next, a substantial fraction of a company's offer (especially an incumbent producer's offer) may entail reuse of part of the language of the previous iteration of competition.

Most importantly, the content of companies' offers will change under MOSA. Instead of explaining to the customer how the firm plans to develop a product to meet the customer's relatively detailed specifications, under MOSA a bid will offer a detailed description of the performance characteristics of a known product. Under the traditional system, the goal of a bid is to convince the customer that the firm is likely to be able to develop a system at a reasonable cost and on schedule. Under MOSA, the prime contractor need not explain the inner workings of the product in great detail, and at least some technical characteristics of the system will be described by references to widely known open interface standards. The much simpler goal of a MOSA bid will be to explain the features of a product and how it meets needs set out in roadmaps.

Figure 1 summarizes the cycle of activities under the MOSA business model.

THE MOSA BUSINESS ENVIRONMENT: WHAT THE GOVERNMENT MUST DO

The MOSA will require a substantial change in the military acquisition organizations' culture and activities. Specifically, the buyer will need to learn to trust competition to control prices and profits, replacing the current system's direct audits of program accounts. The buyer will also need different kinds of technical knowledge than it currently relies on to write specifications under the traditional acquisition system. There is little reason to believe that the American government can make these changes in its acquisition processes for large systems (McNaugher, 1989; Schooner, 2003), but the MOSA is more likely to work for avionics and other subsystems contracts, especially if the equipment is purchased in small batches.

To allow firms to amortize the development costs of their many products that do not win competitions for procurement contracts, the government will have to excise the profit limits from the Federal Acquisition Regulations. In essence, firms need to figure the development costs from their losing bids into their calculation of overhead costs on the production contracts that they actually win. The result will be that procurement prices will be much higher than the development and production costs of the particular equipment being purchased on a particular contract, making that contract seem tremendously profitable if it were examined under traditional cost and pricing rules.

Under the traditional acquisition model, the government faces tremendous political pressure to unilaterally renegotiate contracts that seem “too profitable”: buyers informally impose profit limitations even on fixed-price contracts (Rogerson, 1994). If government auditors ask for too much product-specific cost data, the buyers will face political and cultural pressure to drive prices down. The buyer should not ask questions to which it cannot afford to know the answers. The MOSA contracts will be fixed-price with a different cost structure than under the current business model.

Firms will only have an incentive to invest in risky, innovative research if the buyer allows them to recoup their full portfolio of costs.

Firms will only have an incentive to invest in risky, innovative research if the buyer allows them to recoup their full portfolio of costs. For those products acquired under the MOSA business model, the government’s interest in ensuring affordability will be maintained by competition. Furthermore, because the government will only buy small batches at a time, the buyer will not waste too much money by overpaying on any particular contract, if for some reason competitive pressures temporarily fail to limit the profit margin to a reasonable level. Any purchases on which the buyer accidentally overpays will be the contracts most likely to attract competitors for the next round of competition, driving the price back down.

The other big change in government activity under MOSA reinforces the recent trend away from issuing detailed specifications of technical requirements. Under MOSA, the buyer will simply solicit innovative proposals from industry, based on jointly developed roadmaps that cover broad areas of technology.

But the attenuated government role in technology management will not absolve buyers of all responsibility for technical understanding of military systems. Buyers will need two kinds of complex technical knowledge. First, government buyers will need more technical skill to compare offers and decide best value. Different companies may not offer products with the same features. For example, one bid

may offer exactly the same product that the government purchased in the previous iteration, perhaps at a lower price, while the competing bid may offer a new, upgraded module with extra functionality, presumably at a somewhat higher price. Program managers will need more discretion in their source selection decisions than is allowed by current practices to weigh the value of contractor-led innovations.

To earn that discretion, acquisition officials will need the technical capacity to do more than compare proposals to the specification or statement of objectives in the request for proposals. It may be hard for the operational side of the military to delegate important choices about technical performance to civil servants and uniformed military acquisition officers. Military leaders already chafe at decisions by politicians that trade off performance against cost, but they accept that determining the defense budget is a fundamentally political decision, and military professionals respect civilian control in the United States. Un-elected acquisition officials, however, may be more vulnerable to criticism and pressure from warfighters, if they choose not to buy the most advanced technology available. Acquisition is an inherently political as well as technical process (Dombrowski & Gholz, 2006), and that fact constrains the government's ability to implement MOSA.

The government will also retain an important role in helping to set the open interface standards—a second core technical capability. With defense firms increasing their strength in technology management, they naturally will have more technical advice to offer on the open interface standards. While the government should pay attention to firms' good advice, it also needs an accountability mechanism to guard against contractors' natural—perhaps even subconscious—attempts to seek competitive advantage and higher profitability by steering the evolution of the standards definitions in favor of particular technologies.

Furthermore, the organization empowered to set modular interface standards will need its own acquisition budget. When it determines that a technical standard should change, presumably based on an innovation created by a single firm, that firm's proprietary technology will have to transfer into the public domain.⁶ The standards body will need to pay to purchase that intellectual property. More than just buying a new system, the customer in this case would be buying part of the competitive advantage that the firm expected to enjoy in future rounds of competition.

CONCLUSION: IS MOSA A GOOD IDEA?

The idea of using a modular open systems approach to buy military avionics is relatively new, so at this point assessing its benefits and costs is a fairly speculative exercise. It would certainly be easy to oversell MOSA, and overselling is often an important part of policy advocacy. Convincing politicians, military leaders, and the acquisition bureaucracy to sign on to a new approach will require considerable leadership and salesmanship. But real analysis should support the public approach.

Work on MOSA for military avionics began in the engineering community, where many of its technical advantages “just made sense.” Digging deeper into the technical issues raised important business issues: how will defense companies operate under

the MOSA, and can they be induced to support MOSA by offering them a reasonable chance to earn profits? This description of a possible MOSA business model suggests that businesses can adapt to MOSA, at least for some military avionics projects. But getting past the business problems only reveals political and organizational questions that need to be answered, too, before significant acquisitions will make sense under the new approach. Moreover, MOSA will surely involve a good deal of painful reorganization and overhead investment in creating the standards body—costs that need to be considered carefully compared to the limited volume of MOSA projects that will be available for bidding even under a fully implemented MOSA acquisition system.

The MOSA offers some clear advantages for both the DoD and the defense industry. Systems designed for modular maintenance and upgrades should be able to resolve some of the obsolescence problems of today's equipment, and technology refresh opportunities should facilitate spiral development, allowing equipment to better serve warfighters' needs. The frequent competitions to sell small batches of modules and systems should also allow sensible, flexible decision making to trade off maintenance and acquisition spending. Firms will be eager to take control of their technology management decision-making and to rely on their own strategic decisions about investment priorities.

On the other hand, MOSA must overcome some real limits. The appeal of open standards and the analogy to the world of commercial information technology are frequently used to support casual claims about gains in interoperability. While increasing interoperability is surely an extremely important goal for military acquisition organizations in the new era of network-centric warfare, it is easy to exaggerate the interoperability benefits of MOSA. Not every commercial IT product really “plugs and plays”; hard work is still required, not only to define the interface standards but to maintain them in the face of technological change and mission creep.

It is easy to exaggerate the interoperability benefits of MOSA. Not every commercial IT product really “plugs and plays.”

The organization in charge of maintaining the open architecture standards, supported by government project managers, will need to decide the extent to which the detailed designs for each new product purchased by the military will pass into the open architecture. If too much technology remains proprietary, then the MOSA business model will not reduce costs to the extent that it should, i.e., competitive firms will still have to re-invent the wheel over and over again. But each innovation that changes the standards definitions must be fully paid for at the time that it

is shared with the rest of the defense industry, meaning that incorporating new technologies into the standards definitions will be expensive. Moreover, changing the standards too frequently will set back the gains in interoperability that MOSA is intended to bring and will attenuate the learning-by-doing benefits that designers would otherwise gain by repeatedly using the same architecture.

For other reasons, too, the cost advantage of MOSA may not be large. Buyers will still insist on dictating the technology trajectory, so MOSA will not allow for innovation to move in its most “natural” direction. Appeals to national security and the needs of warfighters carry a tremendous amount of weight, especially in times of war, and technology experts and business strategists will struggle to make their views heard in the roadmapping process.

Furthermore, MOSA requires a delicate balance between the costs and benefits of competition. Development cost savings under MOSA come from getting modules into multiple systems: winning bidders need to succeed repeatedly. At the same time, the margin between price and cost is only controlled by competition, and each competition to sell a batch of equipment will have many losers. Somehow, the acquisition system needs to pay the development costs of all of those losing bidders to keep them in the defense business. The more firms that bid on each increment of technology, the more total development investment that has to be spread across the production runs of successful bids. If too many bidders are attracted to the MOSA market, MOSA could actually increase system-wide costs.

Ultimately, MOSA may be a workable way to solve a number of technical and business process problems for the acquisition of military avionics.

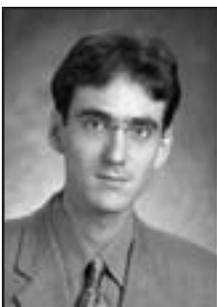
Finally, firms should not necessarily trust the government. First, the ultimate buyers of military systems, Congressional representatives, may not allow firms to set prices high enough to cover their total costs of bidding for MOSA contracts. Politicians are likely to “renegotiate” profit when it seems too high on an individual product. Contracts for subsystems and small modules are likely to be “too far in the weeds” for politicians to notice, but to make a big difference in interoperability, spiral development, and cost savings, MOSA will have to apply to some relatively visible products, too. The only hope is that sales can be packaged in small enough batches not to attract politicians’ attention to the profit margins. But the small batches are a double-edged sword for firms trying to manage their portfolio of risk: the smaller their guaranteed production runs from each contract win, the higher the risk the firms

will have to bear. For MOSA to work, batch sizes need to be set pragmatically (not too small), and that will require a good political solution.

Ultimately, MOSA may be a workable way to solve a number of technical and business process problems for the acquisition of military avionics. But “workable” does not mean that MOSA is a *good* way to solve those problems. Unfortunately, by its very nature, it will probably not be possible to implement small-scale “proof of concept” tests of the modular open system approach: it inherently relies on spreading risk and investment cost across a broad array of projects all at the same time. The DoD Open Systems Joint Task Force is working to implement MOSA, and recent reforms of the defense acquisition process make MOSA a default approach for some systems. With that in mind, defense industry executives and the government acquisition workforce need to understand the business issues, as well as the technical and political ones, in the Modular Open Systems Approach.

AUTHOR'S NOTE

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ENDNOTES

1. A broad selection of this research can be accessed on the web site of the DoD's Open Systems Joint Task Force at <http://www.acq.osd.mil/osjtf/index.html>.
2. The MOSA also faces political barriers. While the Department of Defense can (and already does) include a preference for MOSA in its acquisition regulations, and Congressional leaders in principle support the idea of efficient acquisition and can understand the arguments that have piqued the military customers' interest in MOSA, political leaders nevertheless have good reasons to perpetuate the traditional style of acquisition for the vast majority of defense projects. The traditional acquisition system did not evolve by accident. The MOSA advocates should conduct a separate analysis of the political case for MOSA and should develop a political strategy to broaden MOSA's application in parallel with their technical analyses and the business analysis reported in this article.
3. There is no obvious reason why MOSA would require any shift in the small business set-asides in defense contracting. Prime contractors will simply continue to include small business content as one of the factors to optimize in their trade studies during system development. Meanwhile, the buyers will continue to include small business content as one of the desirable factors that they weigh in determining whether to pay the asking price for a system offered by a prime contractor. As a result of this continuity, the overall shift to the MOSA business model is unlikely to require substantial changes to the business models followed by defense-oriented small businesses.
4. Some products may be too complex and some systems may require too much up-front investment for firms to bear the costs alone. For those systems, the government and the defense industry may continue to use the existing weapons acquisition model.
5. Assuming that the introduction of MOSA does not increase the total amount of equipment that the military demands, any new suppliers that are drawn into the military market by MOSA will have to take work from established suppliers. Presumably, many of the new entrants that MOSA advocates hope to bring into the defense industry will offer modules rather than systems, meaning that they will compete more directly with Tier 2 subcontractors. But established defense firms at all levels of the industry should wonder if one result of the new acquisition approach would be to shrink the per capita market size, hence shrinking their expected business volume, revenue, and employment levels (thought not necessarily their rate of return).
6. "Public" in this context does not mean freely available to anyone. It means open to firms allowed access to classified technical standards available for use by firms in the defense industry.



Image designed by SPC Kelly Lowery, USA

DECISION SUPPORT FOR BEST PRACTICES: LESSONS LEARNED ON BRIDGING THE GAP BETWEEN RESEARCH AND APPLIED PRACTICE

Raimund L. Feldmann, Forrest Shull, and Michele A. Shaw

Today, everyone is looking at best practices for developing a system or making the right choice in acquiring system components. If the right best practices are applied, they help to avoid common problems and improve quality, cost, or both. However, finding and selecting an appropriate best practice is not always an easy endeavor. In most cases guidance, based on sound experience, is missing; often the best practice is too new, still under study, or the existing experiences do not fit the user's context. This article reports on a program that tries to bridge the gap between rigorous empirical research and practical needs for guiding practitioners in selecting appropriate best practices.

Many program managers would agree that using time-tested “Best Practices” can help to avoid common problems and increase the quality of a system, reduce development cost, or both. For instance, in a short survey at the 2004 Conference on the Acquisition of Software-Intensive Systems, 48 senior systems and software managers supported the use of Best Practices. However, the same survey indicated that it is hard to find such Best Practices. The survey identified the following reasons for this problem:

- Best practices often do not exist (i.e., they have not been publicly documented),

- People do not know of a certain best practice, or
- Best practices are not easily accessible (i.e., there is no central place to look for best practices).

The last point matches a more general study by the Delphi Group in which more than 65 percent of the interviewees agreed that finding the right information to do their job is difficult (Delphi, 2002).

Further research conducted by the U.S. Department of Defense (DoD) concluded that barriers for the adoption of best practices included:

- the lack of selection criteria among practices within cost-constrained programs,
- the lack of confidence in the value of such practices by the program offices, and
- the inability to relate practices to the risks and issues programs were facing.

In summary, recognizing good practices and disseminating them to the workforce seems to be a key issue. To address these issues the DoD Acquisition Best Practices Clearinghouse (BPCh) program, sponsored by several offices of the DoD (DS, ARA, National Information Infrastructure [NII], and Defense Procurement & Acquisition Policy [DPAP]), was initiated in 2003 (Dangle, Dwinnell, Hickok & Turner, 2005).

The Fraunhofer Center for Experimental Software Engineering, Maryland (FC-MD) was chosen to develop the initial “proof of concept” for a system to document, evaluate, and disseminate Best Practices. In collaboration with other organizations within the DoD and industry (including Northrop Grumman IT, the Computer Sciences Corporation [CSC], and the Systems and Software Consortium [SSCI]), a prototype system has been built and piloted. It is currently operated and hosted by the Defense Acquisition University (DAU).

THE VISION FOR APPLYING BEST PRACTICES

The DoD vision for the BPCh initiative is to provide more than just a list of Best Practices. It is to provide an integrated set of processes, tools, and resources which will enable information seekers to identify emerging or well-proven practices that have been implemented and proven effective. Practices in the BPCh serve as an information resource to individuals looking for ideas on how to improve quality and become more effective in their job. Clearly, the vision of the BPCh is not to create another “data cemetery,” but to develop an information-sharing network around the BPCh repository which will foster relationships between individuals within DoD and also partnerships between DoD and industry leaders. The following types of questions illustrate usage examples:

- “I just heard about accelerated life testing. Where can I find out if it’s useful or just hype?”
- “They’ve just shortened my testing schedule by 30 percent. Are there any practices that can help me better handle that kind of schedule compression?”
- “I want to add inspections to my quality process. Is it worth the cost and if so, what’s a good first step? Is there someone I can contact in case of any difficulties?”
- “I’ve taken over an acquisition program just before Critical Design Review (CDR). What practices should I look for in my contractors?”
- “I’m in charge of defining a training course as part of the continuing education program for quality improvements. What are state-of-the-art or emerging practices that should be addressed?”

The BPCh has been designed with the understanding that a single practice can never be a “silver bullet” for each and every project/program. This is because some practices may only be useful or beneficial in certain contexts while failing to produce the desired results in others. For example, practices that are absolutely necessary for large, mission critical projects may be too heavyweight for rapid prototyping or Web application development. Practices that work well when the development team is located in the same room may not always scale well when the team is distributed across the country.

Clearly, there exists no one “best” answer. Practices that are best for one user might not be best for the next. Therefore, the BPCh tool responds to user queries with a list of practices rated by how well they fit the project characteristics of the user making the query. The presented selection is compiled using the experience other users have had implementing the practice in a similar context. High-quality evidence about a practice is collected and reported with any necessary caveats, so that information seekers have a sound basis for making up their own minds given their needs.

APPLYING TECHNOLOGY TO DELIVER BEST PRACTICES

To develop the BPCh tool, we applied FC-MD’s EMPEROR approach (Experience Management Portal using Empirical Results as Organizational Resources). This approach makes use of all kinds of available evidential data from research and industry, analyzes and packages it, and disseminates it through a Web-based Experience Base.

The EMPEROR is based on the *experience factory* approach, developed by Basili, Caldiera, and Rombach (1994), which has been successfully employed to facilitate organizational learning at NASA (Basili, et al., 1995), DaimlerChrysler (Schneider & Schwinn, 2001), and elsewhere in North America, Europe, and Australia (Koennecker, Jeffery, & Low, 2000; Mendonca, Seaman, Basili, & Kim,

2001). An experience factory provides a way to analyze results based on practical experience, and package what is learned into an Experience Base for new users of the organization to find and apply.

Since the users of the BPCh come from a wide variety of organizations and programs, any Experience Base will have difficulties in addressing all user needs. To mitigate this problem, EMPEROR is required to: (a) provide transparency to users, so that they can understand the analysis process and the sources of experience and make up their own minds; (b) rate the “trustability” of each of the used sources, so that users can judge the degree of confidence they have in the information provided; and (c) provide a completeness and maturity indicator of the practice information taken as a whole, that is, to perform a self-rating based on how much and what quality evidence can be offered.

DATA STRUCTURE OF A BPCH PRACTICE

These sections describe how these requirements are implemented in the case of the BPCh. In the BPCh, each practice has one associated Practice Record, containing information about the practice and what is available in the Clearinghouse, and zero to many Evidence Profiles, each of which contains a summary of a single organization’s experience using the practice.

A Practice Record consists of:

1. A Practice Detail block, which contains information such as the practice name, a short description, and the completeness and maturity indicator for the experience package.
2. A Practice Summary block, which synthesizes all available evidence data and describes possible application contexts for the practice based on a set of characterizing attributes. This part of the practice record thereby allows different users (i.e., organizations) to make use of the practice.

An Evidence Profile contains an example or report of some type of program that has used this practice, how they applied it, and what results were obtained. Each Evidence Profile contains the same set of context and result fields as the Practice Summary block, except that the information recorded in each field will describe only what has been observed in the given context of the particular piece of evidence. In addition, the data structure of an Evidence Profile contains a field for documenting its classification of the trustability.

TRUSTABILITY OF A SINGLE SOURCE OF EVIDENCE

A 20-point scale rates the trustability of each Evidence Profile. A rating of 1 indicates an anecdotal or informal experience; a rating of 20 indicates that the results of applying the practice are rigorously measured and substantiated. Points are based on the following four dimensions:

- how the practice was applied, ranging from a single pilot study to use on multiple real projects;
- how the results were measured, ranging from an educated guess to a rigorous measurement program;
- how the evidence was reported, ranging from an informal anecdote to a peer-reviewed publication; and
- who reported the evidence, ranging from a second-hand report to someone directly involved on the team.

More information on the rating scale can be found on the BPCh page of the Acquisition Community Connection of DAU (<https://acc.dau.mil/bpch>).

MATURITY OF A PRACTICE RECORD

A 4-point scale is used to rate each Practice Record to quickly inform the user of how much, and what type of, information is known about the practice. As required by EMPEROR, this scale focuses on the quality of the overall accumulated information that is available for a practice (i.e., the synthesized and packaged information in the Practice Record). Based on the available information we describe the practice maturity as:

- No status assigned/Initial entry: A new Practice Record is initially entered into the BPCh when it is nominated by our experts and/or user communities. Typically at this time, only some of the fields in the Practice Detail block are filled in and no Evidence Profiles are available.
- Bronze status/Awareness raised: As soon as any evidence becomes available (i.e., an Evidence Profile has been linked to the Practice Record), the status is set to Bronze Level. For users, the Bronze Level status indicates that the practice has been nominated by our experts and user communities, and received a preliminary check for applicability.
- Silver status/Evaluation performed: When a sufficient set of Evidence Profiles is available, the BPCh experts will fill in the Practice Summary block and the status is set to Silver Level. For users, the Silver Level status indicates that the practice has been selected as promising enough to commission experts in the area to summarize key information. Users can see at a glance what they should know.
- Gold status/Continuously maintained: When the summary has been further evaluated (i.e., vetted) by experts from industry, academia, and government, the status is set

to Gold Level. For users, the Gold Level status indicates that the practice has been through a rigorous analysis by a committee of experts in the practice itself as well as by user representatives. Information on Gold Level practices contains the best and widest-ranging experiences we can find.

CONTENT STATUS OF THE BPCH

We have been piloting BPCh processes and tools by seeding initial content. At this point the BPCh contains 51 practices at all levels of maturity. Practices that have progressed to Gold Level are those, like inspection/technical review, which have a long history of published industrial experience.

Many practices of interest in the area of systems and software acquisition have few documented sources of evidence or experience. Therefore, we are testing different processes for eliciting information from the workforce.

Based on the recommendations of our User Advisory Group, the following types of practices are currently our top-priority areas for additional content:

- Earned Value Management,
- Risk Management,
- Information Assurance, and
- Spiral Development Process.

We hope that visitors to the BPCh tool will try out the offered features for providing short stories about their own experience with practices in these (or any other) areas. We encourage you to provide feedback as to whether you agree or disagree with the existing experiences that have been entered, or thoughts on our BPCh tool in general.

LESSONS LEARNED

Based on our experience with the BPCh program and other knowledge-management projects, we can formulate some observations which make useful rules of thumb for good practices to build such systems. The BPCh program has been organized along three parallel (but interconnected) tracks, which reflects our first lesson learned.

LESSON 1: PROCEED IN MULTIPLE DIRECTIONS SIMULTANEOUSLY

Progress in building a knowledge repository needs to proceed in multiple dimensions simultaneously: content collection, tool development, and outreach.

Although there is often a temptation to view these as tasks that can be done sequentially (e.g., first the tool will be built, then populated, and then it will be advertised to users), we have found this to be an overly simplistic view that diminishes the chance of project success. Constructing the tool prior to collecting actual content and getting users' feedback almost ensures that important user needs will be discovered late and will require much more effort to implement. Populating the content without getting user feedback leads to a high likelihood that the content will not really address user needs. More importantly, content needs to come from the user community, if the repository is to have a long-term life. We have found that for the research team to generate substantial amounts of content is a time-consuming way of recreating what many users already have at their finger tips. Finally, engaging in outreach and building excitement in the community of potential users runs the risk of all prototyping efforts: When told how anything is possible in the final system, users often come up with many wish list features that are not really linked to their everyday needs. Moreover, users often get frustrated with the slow pace of progress when the system actually has to be implemented, and lose interest before the system is fielded.

Constructing the tool prior to collecting actual content and getting users' feedback almost ensures that important user needs will be discovered late and will require much more effort to implement.

To avoid these problems, we have adopted an incremental approach, with content and tool development going on simultaneously and outreach activities to the user community (such as booths at major conferences, or specific User Advisory Group meetings) planned at major milestones. Although this sometimes stretches resources a bit thin, we feel this approach has enabled us to engage periodically with the user community, show them progress since the last iteration, and get feedback on ever more mature versions of the system, with an initial body of content.

LESSON 2: MAINTAIN A CONTINUOUS STREAM OF FUNDING

Because of the interconnected nature of all the tasks listed above, having a stable funding stream is crucial. Requiring the team to take a hiatus from the project after a release is delivered leads to lost opportunities for user involvement (users find it hard to match their schedule to the development team's), leads to new content ideas that miss getting followed up on, may result in the loss of expertise if experienced personnel resources are in transition to other projects during the hiatus, increases the

personnel learning curve encountered at restarts, and may result in flagging interest in the user community since momentum generated during outreach is lost.

LESSON 3: RECOGNIZE THE RELATIVE MERITS OF CONTENT

Our most important lesson learned is a direct implication of the BPCh vision: There is no such thing as a “Best Practice.” Or, to say it more diplomatically: No practice will be “best” for every project. Practices that are absolutely necessary for large, mission-critical projects may be too heavyweight for rapid prototyping or Web application development.

The implications of this lesson are many. Perhaps the most important is related to the tone of the recommendations that users find: Rather than arguing as an expert that readers *should* be following a given practice, or else they are doing something wrong, practices should be recommended to readers on the basis that projects of certain type(s) have found it useful. That is, rather than presenting a foregone conclusion to users, the system should aim at respecting users’ intelligence enough to enable them to draw their own conclusion, providing sufficient evidence as necessary for those decisions to be sound ones.

LESSON 4: UNDERSTAND THE LIFE CYCLE OF BEST PRACTICES

Practices (and practice information) are not static and have a real life cycle. Major paradigm shifts in the software development world can have an impact on which practices are recommended. The practices that seemed to be good fits for most projects, when a waterfall life cycle was the most common approach to software development, are not all equally applicable at the current time, when iterative, spiral, and even agile approaches are probably more representative of the state-of-the-art practice.

Our recommendations regarding a structured life cycle for practice information are:

1. A knowledge repository needs to be continually evolving by accepting information on topics of interest and making it available to users as soon as possible. While some quality checking is necessary to make sure that incorrect, misleading, or incomplete information is disseminated outward, it is better to get information to users as it comes in, than to wait and try to create something perfect. Users should be able to see a timestamp on all information so that they can see if the experiences related are fresh and up to date or come from years ago.
2. However, the desire to get information out quickly should not interfere with the need for validation activities that provide higher confidence in the information. These additional levels of maturity should be noted, to give users more confidence in the information they find, but should not be used as a *precondition* for displaying content.

3. Content needs to be retired *when appropriate*. Practices may have a natural lifespan, since the acquisition and development worlds continue to evolve and change on their own. Practices that were good 10 years ago may not be appropriate given today's constraints or technologies. To avoid users finding obsolete information in the repository, reports need to be generated periodically of which practices have received no updates or new experiences in the longest time.

LESSON 5: APPLY AGILE STRATEGIES AND PROTOTYPING

To create the front end of the BPCh tool, which helps users find candidate practices, explore possibilities, and get more information on practices of real interest, we have found that prototyping and agile strategies are extremely valuable for developing knowledge-management systems.

***Speak to the users in their language.
Do not expect them to learn yours.***

Precisely because of the need for parallel activities in different tracks, and the number of stakeholders involved (tool developers, content gathering team, end user representatives, sponsor representatives), an agile approach is extremely valuable. The implementation of the prototype BPCh tool was carried on in two-week increments, at the end of which a releasable version was always available. At the end of each two-week period, a demonstration and planning meeting was held with as many of the stakeholders as could be present. This approach was necessary to help us coordinate and prioritize the evolving expectations of the users as well as the necessary changes that were suggested by the content development team, based on what they were finding.

As part of this meeting we learned the following lesson:

LESSON 6: USE APPROPRIATE LANGUAGE

Speak to the users in their language. Do not expect them to learn yours. We realized early on that having the greatest possible content in the BPCh repository would not be of much help if the users cannot find it. To address this we needed to provide multiple paths to the information, so that users could select the path that made the most sense to them. Some specific lessons learned here included:

1. Organize around common tasks. The best way to reach users is to organize the contents of the repository according to everyday activities that the user performs. This helps users see the repository less as an additional activity that they need to

make time for, and more as a value-added to the activities that already consume their time. In the case of BPCh, we added several such perspectives (i.e., indexes to the content) based around activities of importance to different segments of the user community (e.g., addressing CMMI practice areas, constructing a systems engineering strategy, and referencing back to common guidebooks).

2. Push as well as pull information. Rather than always expecting users to take time to come to browse the BPCh tool, information can be “pushed” outward to the user on a periodic basis. For example, the user could select some practices of special interest, and when new experiences come in related to these practices a notification is sent via e-mail.
3. Match users to practices based on context similarity. Since no practice will be “best” for every project, it is important to match users to practices using context characteristics. This provides the users with a pick list of practices that may be useful in their particular situation. In addition, it may alert the user to practices that they might not have known about previously. For example, if the user selects a few context variables that describe his/her context, then practices can be prioritized and displayed according to whether they have associated evidence provided by users with similar context information. This is a way of indicating that, even if the practice does not answer a specific search query, users like the current one have found this practice useful and it may be something the user should know.

LESSON 7: DEMONSTRATE PRACTICAL EXAMPLES TO INTENDED USER

To engage in effective outreach activities, aimed at building up an interested and active community of users of the BPCh, we find the following lesson of relevance: You can not show initial users an empty depository.

In line with the idea that building a tool like the BPCh needs to proceed on three tracks in parallel (front-end, content, and outreach) is the lesson that populating the content cannot come after the repository is built. Showing users a fancy front-end without an initial set of real content may get their interest for a short time period, but is not an effective way of building an active user community. Users need to see a small but representative set of content which they can respond to and start generating ideas for the next content or tool release.

LESSON 8: UPDATE CONTENT AND FUNCTIONALITY CONTINUOUSLY

To keep interest engaged, when users do check back to the site they need to see that updates have been made since last time. Content needs to be continuously updated and refreshed to stay abreast of trends.

If users ever become convinced that the repository does not get updated on a regular basis, this often spells the end of their involvement. Rather, they need to be motivated to come back often enough to find new things and hopefully, as they progress, be motivated to submit responses and ideas of their own showing emerging

trends and keeping the content relevant. Thus, user involvement tends to build more user involvement. As users become interested enough to post comments or send new ideas to the repository, other users will continue to be interested to show up to see which comments have been added since the last time and possibly find something of interest to their current situation—and more likely to find something applicable.

One way we have experimented with—to reinforce this concept—is to list on the front page of the BPCh tool the most recently added practices and highlight ones that have been promoted to various maturity levels (Bronze, Silver, or Gold). Thus, one of the first things users see is an indicator of how much progress has occurred since their last visit.

CONCLUSIONS

This article has presented some of the lessons learned with the BPCh program, which aims to document practices and quickly disseminate them to the users. The BPCh, which is based on the EMPEROR approach, makes use of a two-dimensional rating scale. These scales provide users with a quick overview of the trustability and maturity of the stored practice records. The scales allow users to understand and to draw their own conclusions based on a set of evidence from different contexts, from research studies as well as industrial experiences, and using measures at different levels of rigor. Practitioners can rely on this information without reading in detail through the different evidence sources, unless they are interested in the very detailed level of information.

In addition, ways to collect user feedback and trigger discussions are offered to allow a vivid and growing user community. While initial feedback regarding the BPCh tool has been positive (Turner & Shull, 2005), we are continuing to improve the BPCh program and its associated tool through ongoing research, advisory groups, and user community feedback. We are interested in addressing such questions as: “How much extra effort to certify evidence sets and summaries as correct is worthwhile to users?” or “Are there subsets or types of evidence that users will find especially worthwhile?”

We invite you to take a look at our BPCh tool, available at <http://bpch.dau.mil>. We appreciate all feedback, whether it be submitted through the tool or directly to the authors’ e-mail.

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Image designed by TSgt James Smith, USAF

SENSE AND RESPOND: AN EMERGING DoD CONCEPT FOR NATIONAL DEFENSE

Russell A. Vacante

Sense and respond is a concept that is emerging from the context of the network-centric environment. The relative unfamiliarity of this concept within much of the defense community suggests that its meaning and necessity are not completely understood. To help make sense and respond less a catchphrase and more a well understood concept, the text that follows will address: what the term sense and respond means, why it is important to our national security, and its relationship and application to the logistics community. The goals of this article are to provide the reader with a fundamental understanding of the sense-and-respond concept and promote greater dialogue among a larger group of interested parties on this concept.

Sense and Respond (S&R) is a business strategy that is being incorporated for military use in a network-centric environment. The developer of S&R, Steve Haeckel, the director of Strategic Studies at IBM's Advanced Business Institute, adopted this system approach to meet the competitive challenges of the marketplace (Menotti, 2004). Business in the information age, he argues, must respond quickly as an adaptive system to ever-changing, unpredictable customer requests. *Knowing early* and *managing-by-wire* are the cornerstones of this business strategy. The former is getting the jump on the competition, while the latter is using advanced information technology to do so nearly instantaneously. Knowing what is next on the business horizon and having the ability to rapidly adapt a business strategy based upon lightning-speed information being received from the market environment, improves both responsiveness to customers and business performance in the competitive market place. According to now-retired Navy Captain Linda Lewandowski (2003), it is this managerial framework, established by IBM and now being adapted for military

application, that is at the heart of network-centric application and theory. According to Lewandowski, key ideas of S&R include:

1. Demand is ultimately unpredictable, so success depends on speed of pattern recognition and speed of response.
2. Organizations are prearranged in modular business units that can negotiate with one another over commitments.
3. Networks are self-synchronized via a common environment and shared set of objectives.
4. The supply chain is flexible.
5. Information Technology (IT) support enables data sharing, “knowing earlier,” commitment tracking, and role reconfiguration.

Authors Al-Hammouro, Liberatore, Al-Omari, and Phillips (2005) point out that “Networked S&R systems extend human reach beyond temporal and spatial barriers. Remote physical environments can then be monitored, controlled, and affected through communication networks.”

The two business tenets of S&R, knowing early on and managing-by-wire, can be adopted for use by the military. Similar to the commercial-business environment, the military is also increasingly confronted with a fast-changing, unpredictable, technologically sophisticated global threat. A military that can readily adapt, acquire,

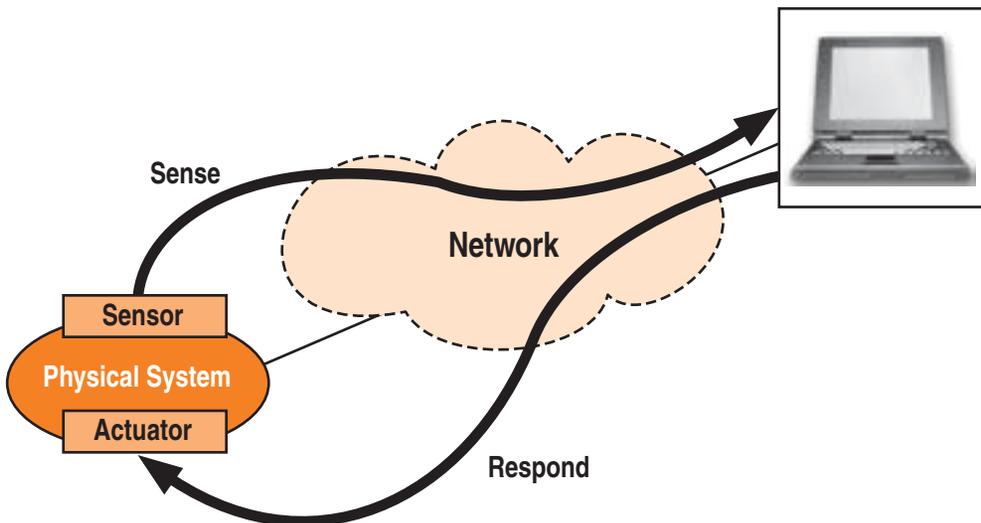


FIGURE 1. SIMPLEST EXAMPLE OF S&R SYSTEM (WITH A FEEDBACK LOOP BETWEEN SENSE AND RESPOND) (GARSTKA & ALBERTS, 2004)

and assimilate information ahead of its adversaries will have the ability to control and dominate the enemy regardless of the type and location from which the threat is being received. The network-centric environment of the military provides the technical framework and resources to receive information early on and to manage that information electronically. This improved networking-communication system can lead to better information sharing and enhanced shared situational awareness (Army Business Transformation Knowledge Center, 2006). It can also improve the quality of decision making. Therefore, within the defense community, the concept of S&R has significance beyond the use of advanced technology. Its primary functions are leadership, decision making, and empowerment.

In a network-centric military environment that applies the S&R approach, the nature of leadership takes on a specific characteristic. Leadership does not effectively occur in a hierarchical structure, but rather occurs in a flatter organizational structure and is collaborative in nature. In networked structures, complex problems are solved by people from diverse organizations working together in ad hoc and sometimes virtual teams. Decision making is distributed throughout the organization. There are few formalized rules and procedures regulating behavior. As summarized by Garstka and Alberts (2004), “Individuals in these organizations come together to solve a particular problem or set of problems. Their interactions are guided by the nature of the problem, which determines the makeup of participants based on their different expertise.”

With respect to the type of decision-making authority mentioned above, Garstka and Alberts (2004) note that:

Rather than relying on rigid and formalized rules and regulations, these organizations will be characterized by a much more dynamic and evolving rule set. Individuals will need to be able to form appropriate bonds and identify with a variety of groups, from ad hoc co-located teams to virtual teams and networks of teams. Status will necessarily result from performance as very few roles will endure long enough to have institutionalized reputations. Importantly, these new organizational structures will require a synchronous perception of time; multitasking being the rule not the exception. Authority will be distributed rather than centralized and finally, the orientation toward the environment will shift from one based on control to one based on adaptation.

Furthermore, Al-Hammouro, et al. (2005) state that:

[The] S&R control environments can differ radically in complexity and in applications. Such environments can range from simple linear systems as in the case of a thermostat to very complex ones, which might include systems of subsystems, as in the case of unmanned autonomous vehicles (UAVs) and in the case of value-chains in manufacturing. Moreover, some systems may include different

hierarchical levels of complexity abstraction. For example in UAVs, there are several hierarchical levels. At the lowest level is the direct force level. At this level, the on-board controller issues tasks, such as rotating motors forward or reverse, based on feedback information supplied by sensors (this represents local S&R). At the highest level of abstraction are software agents. Software agents carry out high-level tasks, and are responsible for coordinating multiple UAVs into task-oriented teams, which can have impact on different applications, e.g., military transformation. On the other hand, an online auction S&R system would comprise only the software-agent level.

Agility is a prominent feature of the sense-and-respond concept, much as it is for network-centric warfare. By closely examining the definition of agility, we can quickly come to understand that there is a symbiotic relationship between agility and empowerment: “Agility provides the ability to be effective in changing, nonlinear, uncertain, and unpredictable environments. Agile organizations are the result of an organizational structure, command and control approach, concepts of operation, supporting systems, and personnel that have a synergistic mix of the right characteristics. The term agile can be used to describe each component of an organization’s capabilities and/or an organization that can instantiate many different mission types” (Garstka & Alberts, 2004, p. 21). A 2005 Rand study of network-centric operations provides many threads of discussion which suggest that the implementation of S&R in an operational environment is, to a high degree, predicated on empowering soldiers throughout the brigade with decision-making authority. The study notes that “the [situational awareness/situational understanding] afforded platoon leaders and commanders by the lower [Tactical Internet] and Force XXI Battle Command Brigade and Below (FBCB2) [gave them] the ability to maneuver their forces and close with and destroy the enemy during urban operations” (Gonzales, et al., 2005). The author goes on to state: “An important hypothesis captured by the NCO CF (conceptual framework) is that individual and shared sense-making are improved by the quality of interaction supported by the network.” This quotation suggests that command decisions are knowledge-based and demand-driven, and “depend on highly adaptive, self-synchronizing, and dynamic physical and functional processes, employing and enhancing operational cognitive decision support” (Office of Force Transformation, 2005). The type of speed and recognition required of S&R needs an empowering organization structure, a structure that is atypical of decision-making processes within most Department of Defense organizations.

THE IMPORTANCE OF SENSE AND RESPOND

The reality of 21st century warfare is that it can occur at any place, anywhere, at anytime, and take many forms. The rules, norms, and expectations of warfare are highly unpredictable. The Office of Force Transformation (2003) states that there is an:

Emerging global security environment [that] represents a new set of challenges and threats, and fundamentally changes the rules of how America fights its wars. The new threats are broader and include global, regional, and local elements. They are non-state, multi-dimensional, flexible, distributed, information aware, and rapidly adapt to U.S. strategies and tactics. They are unconstrained by the values that guide America’s approach to warfare. Increasingly, these threats have at their disposal asymmetric, inexpensive, and competitive methods of creating large-scale effects.

This new global security environment is complex and highly unpredictable. Threats to U.S. security may be rooted in international organizations, nation states, rogue states, terror organizations, or any combination thereof (Office of Force Transformation, 2004a). Our survival depends, to a high degree, upon our ability to quickly adapt and appropriately respond to one or more of the changing challenges discussed above. The S&R system provides the technology, information, organizational structure, and cognitive speed and effectiveness to prevent minor threats from such entities turning into large-scale destructive action against the United States. Since the speed, intensity, and nature of the threat is highly unpredictable, our response capability has to be extremely agile. This agility requires “system” response at the Joint military level. “Sense and Respond is a transformational network-centric concept that enables Joint effect-based operations and provides precise, agile support” (Office of Force Transformation, 2004a, p. 3).

TABLE 1. DISPLAY OF S&R LOGISTICS ATTRIBUTES

FOUNDATIONS FOR S&R	GUIDING PRINCIPLES FOR JOINT LOGISTICS AND DYNAMIC ADAPTABLE OPERATIONS
Dynamic adaptation of logistics support, using situation and commander’s intent-adapted business rules, risk thresholds, and multidimensional situation-relevant metrics	Emphasize achievement of commander’s intent with speed and quality effects
Integration of operations, intelligence, and logistics functions and activities	Enable and sustain effects-based operations, using reconfigurable joint/allied/coalition/treaty organization force capabilities as building blocks
Total situation awareness: dynamic knowledge of evolving commander’s intent, strategic, operational, and tactical situation, the global and local environment, and logistics and force capability status	Provide risk-mitigated situation-aware preparedness, readiness, deployment, employment, and sustainment options to the commander across the full range of military operations
Functions and activities governed by business rules that respond dynamically, in real time, to total situation awareness	Replace the cyclic nature of planning and execution with a continuous application of total situation awareness to current and future operations
Rule-based risk-assessed and mitigated dynamic adaptation of functions, activities, processes, organizations, supply, and support	Eliminated process lines, structural lines, organization overhead, and constraints

TABLE 1. DISPLAY OF S&R LOGISTICS ATTRIBUTES (CONTINUED)

FOUNDATIONS FOR S&R	GUIDING PRINCIPLES FOR JOINT LOGISTICS AND DYNAMIC ADAPTABLE OPERATIONS
Cognitive decision support that is knowledge-guided, recognizes patterns and anomalies, and mines feedback and experience to adapt operations	Provide deterrence and alter initial conditions by developing kinetic and potential force capabilities relative to a potential adversary's courses of action to: deny benefits, impose costs, and induce restraints
Network-centric operations and warfare as an operational concept and as an infrastructure, including provisions for robust, secure, agile, and assured operations, and operations when network resources are scarce	Support expeditionary force projection and application for all military operations, emphasizing force-to-object maneuver
Coordination, collaboration, and coherence of operations through robust interfaces and shared knowledge across military domains, in multinational operations, and with government, civilian, and private organizations	Provide logistics for force capabilities from the point of effect to the source of support, using autonomous, peer-to-peer, and brokered demand and supply
Management of strategic, operational, and tactical envelopes of operations coordinated among the operations, intelligence, and logistics domains through common understanding of commander's intent and the situation	Embed evolutionary development of doctrines, tactics, techniques, procedures, and organization into the adaptation of functions and activities
Broadened asset visibility across: functions; services; multinational partners; government, non-government, and private agencies; the CONUS/OCONUS sustaining base; commercial and opportunistic sources of supply and services; and captured and confiscated resources	Dynamically adapt current and future operations to respond to evolving commander's intent and to the known and anticipated status of situation, environment, and force capabilities
Proactively sustain and support the force, using knowledge-guided adaptation, prediction, and anticipation to preemptively prepare and provide logistics resources	Defeat with modest forces (economy of power) and modest reinforcement (demassification)
Management of the mosaic of logistics resources and force capabilities and response to demand and events using advanced information technologies	Increase speed of command, accommodate dispersed, distributed forces, manage high rates of change, and respond to closely coupled events
Dynamic adaptive command and control, using business rule-adapted, coordinated, synchronized event processing, data/information/knowledge development, awareness, and sharing, and collaborative functions and activities	Accommodate the compression of (and simultaneous distributed response to) the strategic, operational, and tactical levels of war, including non-contiguous, non-linear operations
Tailored, precise logistics enabled through global situation awareness and knowledge of commander's intent, and local optimization of resource allocations, distribution, and employment	Support precision engagement/strike, decisive coercive operations, adaptive warfare, operational/tactical agility, and integration of offensive and defensive operations

Table 1 is a display of S&R logistics attributes. It indicates, among other things, that S&R is a concept that is applicable to all units and troops engaged in activity within the network-centric, joint battle space. Of equal importance, Table 1 underscores the fact that logistics is now an integral part of the warfighters' operational and tactical planning and execution (Office of Force Transformation, 2004b).

APPLYING SENSE AND RESPOND APPLICATION TO THE LOGISTICS COMMUNITY

The logistics community must be prepared to meet the full range of military operations with the speed and agility that is expected from the warfighter. It must be able to distribute “guns, bullets, bread, and butter” and adapt its activities and support to quick, ever-changing threat environments. Lewandowski (2003) points out that “Hierarchical, stovepipe logistics chains cannot support distributed, adaptive operations.” The S&R for the logistician means that logistics support has to be push-and-pull in nature. Push requires anticipating where the forces will be and delivering the right configured package in the right place, at the right time, in the right amount. It is more than just-in-time, total asset visibility. It requires logistics to function as an integral part of a system. The very S&R system that jump-starts our military into action must be utilized by the logistician to support the commander's intent. As the fighting force becomes lighter and more agile, the effectiveness and efficiency of logistics should follow in kind. It must be flexible, agile, and fast. The logistics tail and footprint have to be significantly reduced in order to support and sustain the troops.

SENSE-AND-RESPOND LOGISTICS

Sense-and-Respond Logistics (S&RL) is a transformational network-centric concept that enables joint effects-based operations and provides precise, agile support. The S&R Logistics relies upon highly adaptive, self-synchronizing, and dynamic physical and functional processes. It predicts, anticipates, and coordinates actions that provide a competitive advantage spanning the full range of military operations across the strategic, operational, and tactical levels of war. The SR Logistics promotes doctrinal and organizational transformation, and supports scalable coherence of command and control, operations, logistics, intelligence, surveillance, and reconnaissance.

Implemented as a cross-Service, cross-organizational capability, S&R Logistics provides an end-to-end, point of effect to source of support networks of logistics resources and capabilities. Within S&R Logistics, every entity, whether military, government, or commercial, is both a potential consumer and a potential provider of logistics. It delivers flexibility, robustness, and scalability for joint expeditionary warfare through adaptive, responsive, real-time, demand and support networks within U.S., allied, and coalition operations (Office of Force Transformation, 2004, p. 5).

As indicated by the Office of Force Transformation (2004c), “Sense and respond logistics will focus logistics support towards direct correlation to total situation awareness. It will anticipate and proactively support future operations, and predict future situations.” The ability to manage-by-wire will help fulfill the commander’s intent. By fully integrating logistics with operations and intelligence assets, logistics resources can be better exploited. These resources will be based on the commander’s intent, and will reduce risk and uncertainty of delivery and support as the redundant iron mountains of equipment and supplies give way to precisely tailored packages distributed by a transportation network that can transverse the full spectrum of the battle space.

The S&R Logistics Concept is based upon the power of the network (Office of Force Transformation, 2004a). It uses networks to support distributed, adaptive operations in a seamless and highly flexible manner. It is a transparent logistics system that the warfighter can depend upon and trust to deliver supplies and

TABLE 2. LOGISTICS: PRE- AND POST-TRANSFORMATION

PRE-TRANSFORMATION	POST-TRANSFORMATION
Linear	Nonlinear
Chains	Networked
Use-Based	Effects-Based
Service Stovepipes	Cross-Service Mutual Support
Functional Stovepipes	Cross-Enterprise
Title Ten-Driven	Joint Logistics
Pre-Planned	Dynamic Continuous Planning and Execution
Poor Ops/Log ISR Integration	Net Warrior Ethos
Reactive	Anticipatory
Parametric Analysis-Based	Collaborative
Hierarchical	Networked
Monolithic	Distributed, Modular
Poor Scalability	Dynamically Scalable
Not Flexible	Flexible
Consumption-Based	Adaptive, Cognitive
Mass	Speed of Effect
Attrition	Effects-Based
Service Perspective	Joint Coherence
Efficiency	Effectiveness
Highly Optimized	Effective
Brittle, Rigid Supply Chains	Robust, Flexible Demand Networks

munitions to project power and sustain their mission. Table 2 indicates how S&R Logistics will change the manner in which logistics will function for the greater part of the 21st century. In the post-transformation environment, stovepipes become a relic of the past. Logistics, as with warfighting, will become a joint endeavor. Networking will be the glue that will successfully implement cross-Service and cross-enterprise support.

The lightning speed at which this responsive, collaborative, anticipatory logistics system must function requires a network-centric communications system. This system must be extremely robust and highly tolerant of nonlinear, nonhierarchical communications for planning and logistics support for a broad range of missions anywhere in the world.

THE FEASIBILITY OF IMPLEMENTING S&R

The feasibility of implementation of S&R is closely related to the necessity for implementation. The former Army Chief of Staff, General Eric Shinseki, recognized that the threat to U.S. national security is taking on a radically different form in the 21st century. Our forces have to be fast, agile, and highly mobile to respond to unpredictable sources of threat, regardless of their source. Network-centric technology, and in particular S&R operations, can enable such forces. Therefore, S&R feasibility is closely linked to force transformation and associated strategic, operational, and tactical operations in a joint warfighting environment.

The feasibility of implementation of S&R is closely related to the necessity for implementation.

The S&R and the lighter, more agile force envisioned by General Shinseki are designed to work together. Both are complex to implement. The technical training associated with both is unprecedented. Both require a well educated workforce that has received extensive training in both warfare methodologies. In addition, the active and reserve components must be trained to the same degree and in the same manner. One important lesson-learned from our current military operations in Iraq is that the active force has been better trained to use advanced technology than their reserve component counterparts. The reserve forces often receive their first exposure to advanced technology shortly after their arrival into the theater. The S&R tactics and technology promise to be considerably more complex than much of the advanced technology currently being used in Iraq. The military op-tempo is expected to continue well into the future, suggesting that active and reserve forces will continue to be deployed together throughout the world.

The demographic and geopolitical backdrop of this situation is grounded in predications that indicate the global population will grow from 6 to 8 billion by 2025, which will help to accelerate international migration that will, in turn, contribute to global nation-state instability. Other issues are predicted to contribute to global instability. For example, the current National Security Strategy Plan and National Military Strategy are written to respond to the increased fragmentation of states along tribal, religious, and ethnic lines, as well as the proliferation of new states, and the loose alignment of regional political and economic associations, such as the Association of Southeast Asian Nations (ASEAN) and Gulf Coordination Council. If this trend continues, the demand on our military forces will be the same or greater than today. To cope with the sociopolitical challenges of the 21st century, it is imperative that S&R capability be adopted. The feasibility of implementation of S&R, however, is contingent upon ensuring that there is a cross leveling of training among the active and reserve component forces.

CONCLUSION

What has been briefly demonstrated in this article is that S&R is a viable concept that needs to be rapidly adopted in response to the diverse military challenges of the 21st century. The U.S. military has to function as a *system* in order to properly implement S&R. The decision maker must realize that S&R is not a concept to be solely implemented at the point of the spear. Logistics and related *ilities* are just as integral to the system as the combat elements. The feasibility of successfully implementing S&R is highly dependent on appropriate education and training of the entire force, requiring a great deal of time and effort that cannot take place in the battle space during the fog of war. The U.S. capability to respond decisively to the military challenges of the 21st century requires the near-term implementation of S&R. With an understanding of S&R and its relationship to national security, the logistics community, and the necessity/feasibility of application, the defense community can come a step or two closer towards developing a S&R plan for implementation.



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Image adjusted by TSgt James Smith, USAF

APPLICATION OF STRUCTURED DECISION- MAKING TOOLS TO DEFENSE ACQUISITION

LCDR John R. Gensure, USN (Ret.)

The Defense Acquisition System is heavily dependent upon quality decision making. The application of structured decision-making tools to Defense acquisition problems can significantly assist the decision maker in the analysis of complex decisions, particularly those involving uncertainty, risk, and multiple objectives. Decision analysis and operations research are structured decision-making tools that can aid the decision maker in avoiding biases, documenting decision methodologies, and making group decisions. Overall, the systematic application of structured decision-making tools can significantly increase a decision maker's insight into the complex decisions that are characteristic of the Defense Acquisition System.

Defense acquisition decisions are often of extremely high importance and consequence, as the lives of U.S. Armed Forces members and the people they protect may depend on the quality of those decisions. Decision analysis and operations research are two different structured decision-making methodologies that can be employed to significantly improve the quality of decision making and problem solving, as well as provide the decision maker with greater insights into the decision at hand. Decision analysis accentuates the decision maker's objectives, preferences, and attitudes towards risk (Goodwin & Wright, 2004). Operations research emphasizes system understanding and the formulation of a mathematical model of the system (Winston, 1994). The nature of the decision may indicate whether decision analysis or operations research is most applicable, but in many cases the application of more than one technique may help the decision maker view the problem from multiple perspectives. The methodologies often complement one another, providing

the decision maker with significant insight into the decision at hand (Modjeski, 2004).

UNSTRUCTURED VERSUS STRUCTURED DECISION MAKING

Decision makers develop a personalized set of decision-making tools and strategies over time based on their experience and education. When faced with a decision, decision makers employ a strategy that they believe to be the most applicable based on the situation. Characteristics of the decision, such as urgency, importance, consequence, and available information, all affect a decision maker's choice of strategy. For common decisions of low importance and consequence, decision makers typically employ unstructured decision-making tools and methods, called *heuristics* (Gigerenzer, Todd, & ABC, 1999). Heuristics may provide satisfactory courses of action but often do not provide the optimal course of action in a given decision (Goodwin & Wright, 2004). For some simple Defense acquisition decisions, such as the purchasing of copier paper, the minimal complexity and low consequence of the decision may not warrant the time and effort required to employ a structured decision-making tool. For the purchasing of copier paper, a decision maker might utilize a heuristic strategy where he/she will rank the various attributes of available vendors in order of importance and choose the vendor that provides the highest value on the most important attribute (Goodwin & Wright, 2004). Should the lowest purchase price be the most important attribute, corresponding to the objective of minimum cost to the government, the decision maker will choose the vendor that provides copier paper that meets minimum requirements at the lowest price. If two vendors provide copier paper at the same lowest price then the decision maker will choose the vendor that provides the most value on his/her next most important attribute, such as delivery time.

Most Defense acquisition decisions are significantly more complex than the purchasing of copier paper, and therefore the use of unstructured heuristics is not appropriate. In Defense acquisition, decision makers are typically faced with complex decisions involving multiple objectives. As indicated in the Federal Acquisition Regulations, Part 1.102 (2005):

The vision for the Federal Acquisition System is to deliver on a timely basis the best value product or service to the customer, while maintaining the public's trust and fulfilling public policy objectives. Participants in the acquisition process should work together as a team and should be empowered to make decisions within their area of responsibility.

For Defense acquisition decisions of high importance and consequence, a decision maker should employ a compensatory, structured decision strategy to arrive at an optimal course of action versus an unstructured heuristic strategy. Unlike heuristic strategies, which are noncompensatory, a compensatory strategy requires the decision

maker to not only rank the importance of multiple objectives and their associated attributes, but to make trade-offs between various attributes. Poor performance by a decision option on one attribute might be offset by superior performance on several other attributes (Goodwin & Wright, 2004). In the case of the copier paper example, the decision maker might choose to purchase copier paper from a more expensive vendor based on the vendor's history of superior delivery times, responsiveness, and product quality. Decision analysis and operations research are compensatory, structured decision-making tools that can provide the decision maker with significant insight into complex defense acquisition decisions.

DECISION ANALYSIS

Robert T. Clemen (1996), Associate Professor of Decision Sciences, Duke University, provided the following summary of the objectives of decision analysis and outlined the decision analysis process as shown in Figure 1:

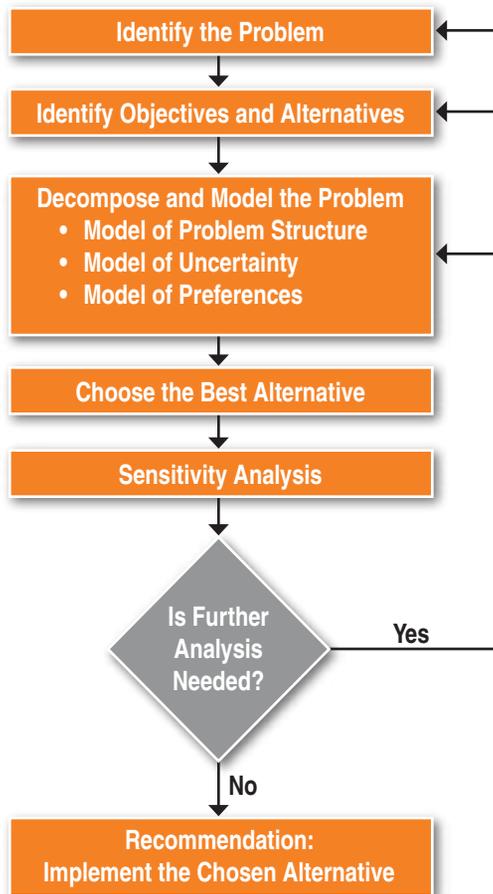


FIGURE 1.
THE DECISION ANALYSIS PROCESS (CLEMEN, 1996; VAN DORP, 2003)

I subscribe to the notion that the objective of decision analysis is to help a decision maker think hard about the specific problem at hand, including the overall structure of the problem as well as his or her preferences and beliefs. Decision analysis provides both an overall paradigm and a set of tools with which a decision maker can construct and analyze a model of a decision situation...the purpose of studying decision-analysis techniques is to be able to represent real-world problems using models that can be analyzed to gain insight and understanding. It is through that insight and understanding—the hoped-for result of the modeling process—that decisions can be improved.

Decision analysis commences with a thorough identification of the problem and then places heavy emphasis on the subjective judgment of the decision maker. The objectives of the decision maker along with his/her preferences are explored and evaluated during the process of decomposing and modeling of the problem. Decision analysis tools, including the Simple Multi-Attribute Rating Technique (SMART) and multi-attribute utility theory, are utilized to elicit value and utility functions from the decision maker as well as his/her attitudes towards risk (Goodwin & Wright, 2004). After the preferred alternative is identified, sensitivity analysis is conducted. During sensitivity analysis, the decision maker investigates the dependencies of preferred solutions on the inputs obtained during the elicitation and modeling stages of the decision analysis process prior to implementation of the chosen alternative (Goodwin & Wright, 2004). Employment of the decision analysis process can provide Defense acquisition decision makers with new insights into complex procurement decisions.

SMART DECISION ANALYSIS TOOL

The SMART provides the decision maker with a compensatory, structured analytical process for evaluating complex decisions that involve multiple objectives where uncertainty is not a factor (Edwards, 1971). The SMART's relative simplicity, speed of application, and transparency—i.e., easy for individual and group decision makers to understand—make the tool an extremely valuable asset to the decision maker. When compared to noncompensatory, heuristic-based decision methods, SMART can provide the decision maker with a significantly greater understanding of complex Defense acquisition decisions (ODPM, 2004; Goodwin & Wright, 2004).

The first stage of SMART is to identify the decision maker. In the case of a new Defense weapons system procurement, the acquisition team members are the decision makers. In the second stage, the alternative courses of action are identified. For a simplified weapon system procurement example, the alternatives may be limited to the procurement of weapon system 1 or weapon system 2. In stage 3, the attributes that are relevant to the decision are identified. For this example, the attributes are determined to be cost, development schedule, destructive power, accuracy, and speed of employment. A value tree is displayed in Figure 2 (Goodwin & Wright, 2004).

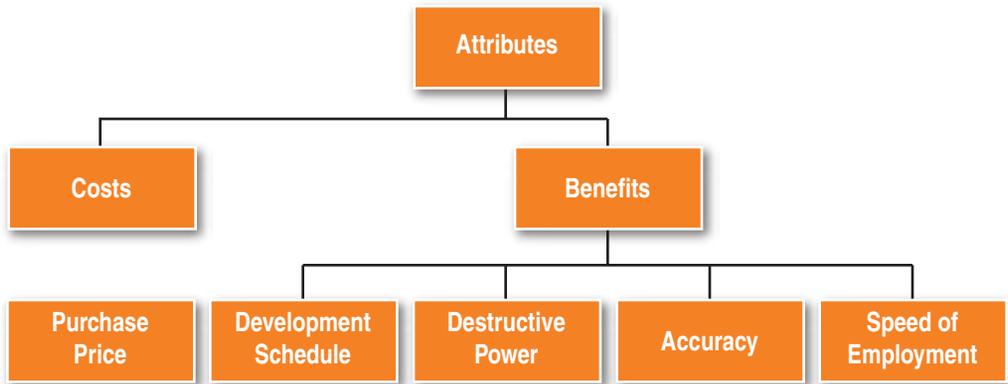


FIGURE 2.
VALUE TREE FOR WEAPONS SYSTEM PROCUREMENT EXAMPLE

In stage 4, values for the performance of weapon system 1 and weapon system 2 on each individual attribute are computed. As all of the attributes for the weapon system procurement example can be denoted with quantifiable variables, Table 1 provides the variables and their associate value functions for weapons systems 1 and 2. In each case the preferred variable is assigned a value of 100 and the least preferred variable is assigned a value of 0 (for problems with additional alternatives, values between 100 and 0 would also be assigned as appropriate) (Goodwin & Wright, 2004).

TABLE 1.
ATTRIBUTE VALUES FOR WEAPON SYSTEM PROCUREMENT EXAMPLE

Attribute	Weapon System #1		Weapon System #2	
	Variable	Value	Variable	Value
Purchase Price	\$1,000,000	0	\$750,000	100
Development Schedule	12 months	100	14 months	0
Destructive Power	2,000 lbs	100	1,750 lbs	0
Accuracy (Circular Error Probable (CEP))	100 m	100	150 m	0
Speed of Employment	1 minute	0	30 sec	100

In stage 5, the decision maker is asked to determine weights for each attribute to reflect his/her preferences between the attributes. The SMART (Edwards, 1971) model is a linear additive model where the total value for each decision option (weapons systems 1 and 2) is the sum of the values assigned to each individual attribute for the option multiplied by its respective weight, as shown in Equation 1 (ODPM, 2004):

$$S_i = \sum_{j=1}^n \omega_j s_{ij} = \omega_1 s_{i1} + \omega_2 s_{i2} + \dots + \omega_n s_{in} \quad \text{Equation 1}$$

The weights are determined to reflect the decision maker's preferences between attributes. A simple procedure would be to have the decision maker rank the attributes in order of preference. Unfortunately, a simple ranking method might provide too much weight to an attribute that is important to the decision maker but has little bearing on the decision at hand (Goodwin & Wright, 2004). For example, if the difference in length of development schedule between the two alternatives was only one week, the importance of development schedule on this specific decision may be negligible, but the importance to the decision maker of development schedule as an attribute may be significant. To avoid such an issue, the decision maker is encouraged to assign swing weight to each attribute. Edwards & Barron (1994) referred to the use of the SMART method with swing weights as SMARTS, which stands for SMART with Swings (ODPM, 2004).

To determine the swing weights, the decision maker is asked to rank the attributes based on the swing from least to most preferred variable of each attribute versus the swing from least to most preferred variable of the other attributes. The attribute with the lowest importance is assigned a weight of 0 and the one with the highest is assigned a weight of 100. The remainders are assigned intermediate values and then all the values are normalized (Goodwin & Wright, 2004). The results for the weapon system procurement example are shown in Table 2.

TABLE 2.
WEIGHTS FOR WEAPON SYSTEM PROCUREMENT EXAMPLE

Attribute	Swings	Original	Normalized
		Swing Weights	Swing Weights
Purchase Price	\$250,000	100	40
Development Schedule	2 months	30	12
Destructive Power	250 lbs	0	0
Accuracy	50 meters	70	28
Speed of Employment	30 sec	50	20
Total		250	100

Equation 1 can now be utilized in stage 6 to determine the overall values for weapons systems 1 and 2 portrayed in Table 3. Table 3 demonstrates how attribute swing weights and attribute values can be combined using Equation 1 to provide insight to the decision maker regarding the weapon system procurement decision. Purchase of weapon system 2 received a higher total value than that received by weapon system 1. After making a provisional decision in step 7 to purchase weapon system 2 based on the results in Table 3, the decision maker should complete step 8 of SMARTS. In step 8, sensitivity analysis is completed to determine how the results of the analysis might change based on changes in the values and weights provided by the decision maker. Step 8 is very important (and often neglected) as the results obtained

TABLE 3. PRODUCT OF VALUES AND WEIGHTS FOR WEAPONS SYSTEM PROCUREMENT EXAMPLE

Attribute	Weapon System #1			Weapon System #2		
	Value	Weights	Product	Value	Weights	Product
Purchase Price	0	40	0	100	40	4000
Development Schedule	100	12	1200	0	12	0
Destructive Power	100	0	0	0	0	0
Accuracy	100	28	2800	0	28	0
Speed of Employment	0	20	0	100	20	2000
Total/100			40		60	

will provide the decision maker with an enhanced understanding of the problem and better confidence in the final Defense acquisition decision (Goodwin & Wright, 2004).

UTILITY THEORY DECISION ANALYSIS TOOL

Although more complicated than SMARTS, utility theory provides the decision maker with a compensatory, structured analytical process for evaluating complex decisions that involve one or more objectives where uncertainty and risk are factors in the decision. A utility function can be derived from the decision maker's attitude towards risk and utilized to provide significant insight into the decision at hand (Goodwin & Wright, 2004). According to the University of Michigan Decision Consortium (2004):

Utility theory is an attempt to infer subjective value, or utility, from choices. Utility theory can be used in both decision making under risk (where the probabilities are explicitly given) and in decision making under uncertainty (where the probabilities are not explicitly given).

To continue with the weapon system procurement example, single attribute utility theory can be utilized to evaluate development schedule risk for weapons systems 1 and 2. In their work *Theory of Games and Economic Behavior*, John von Neumann and Oskar Morgenstern initiated both game theory and the theory of choice under uncertainty (Economics, 2004). Von Neumann and Morgenstern's (1944) theory of utility can be employed in the weapons system procurement example to elicit a utility function for the decision maker's attitude towards risk (Goodwin & Wright, 2004). The decision choices, either the procurement of weapon system 1 or 2, along with the probabilities of the development schedule outcomes based on the chosen weapon system, are represented in the decision tree shown in Figure 3.

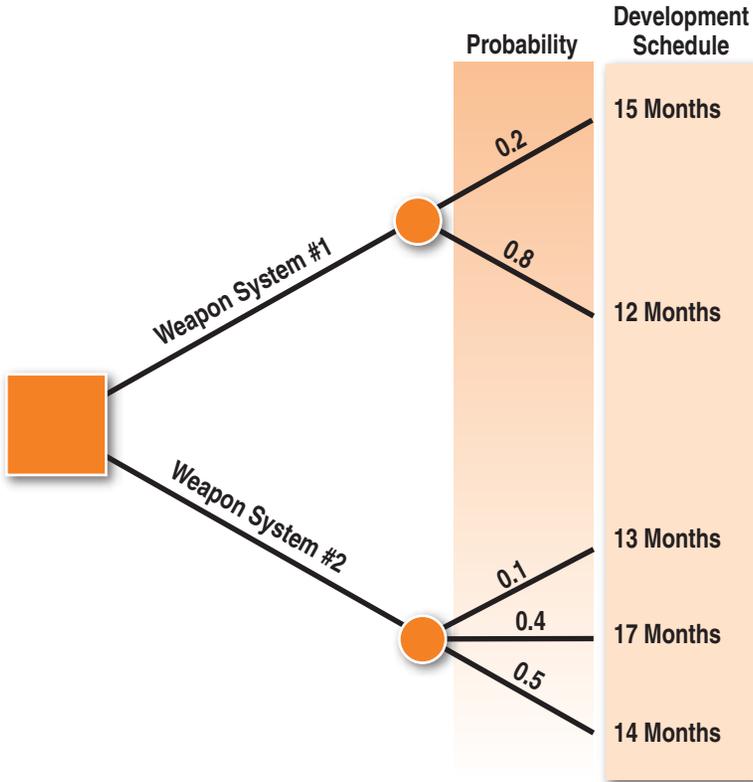


FIGURE 3.
DECISION TREE FOR WEAPONS SYSTEM PROCUREMENT EXAMPLE

Derivation of the decision maker’s utility function for the possible development schedules shown in Figure 3 can be accomplished by presenting the decision maker with a series of hypothetical lotteries. First, the best outcome (12 months) is assigned a utility of 1.0 ($u[12\text{ months}] = 1.0$). Next, the utility of the worst outcome is assigned a utility of 0.0 ($u[17\text{ months}] = 0.0$). Intermediate utilities are calculated by conducting an elicitation session with the decision maker. For each intermediate outcome, the decision maker is asked to choose between various hypothetical lotteries which offer a specific percentage chance of achieving the best outcome and the corresponding percentage of achieving the worst outcome. Once the decision maker indicates indifference between a presented lottery and the actual outcome, the outcome is assigned the utility of the lottery (Goodwin & Wright, 2004).

TABLE 4.
UTILITIES FOR WEAPON SYSTEM PROCUREMENT EXAMPLE

$u(16\text{ months}) = 0.5 * u(12\text{ months}) + 0.5 * u(17\text{ months}) = (0.5) * (1.0) + (0.5) * (0.0) = 0.5$
$u(15\text{ months}) = 0.7 * u(12\text{ months}) + 0.3 * u(17\text{ months}) = (0.7) * (1.0) + (0.3) * (0.0) = 0.7$
$u(14\text{ months}) = 0.8 * u(12\text{ months}) + 0.2 * u(17\text{ months}) = (0.8) * (1.0) + (0.2) * (0.0) = 0.8$
$u(13\text{ months}) = 0.9 * u(12\text{ months}) + 0.1 * u(17\text{ months}) = (0.9) * (1.0) + (0.1) * (0.0) = 0.9$

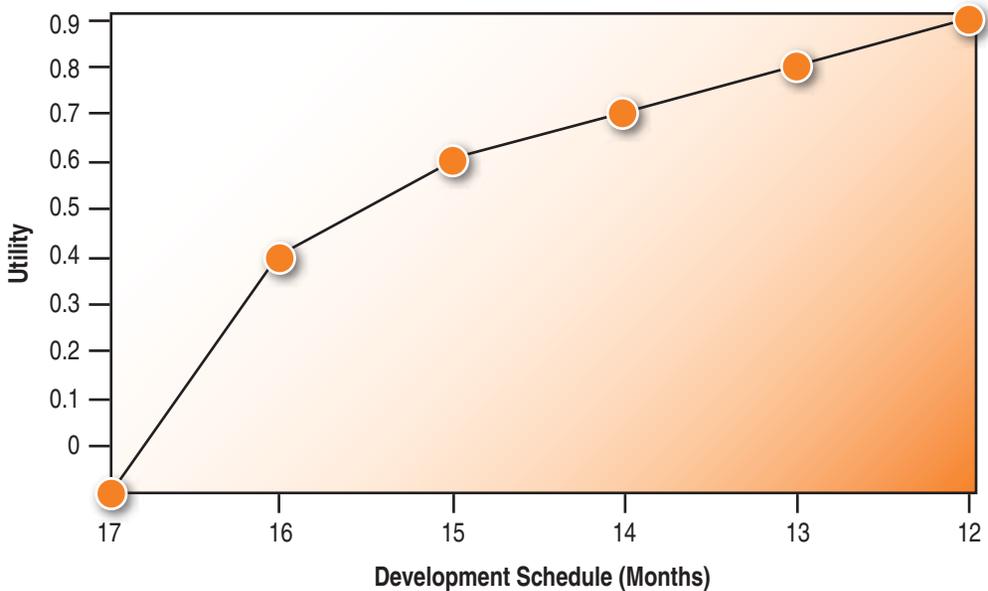


FIGURE 4.
UTILITY FUNCTION FOR WEAPONS SYSTEM PROCUREMENT EXAMPLE

For example, the decision maker is asked to choose between (a) the certainty of a 16 month development schedule or (b) engaging in a lottery where there is 50 percent chance of a 12-month development schedule and 50 percent chance of a 17-month development schedule. If the decision maker indicates that he/she is indifferent between the two choices then the utility of a 16-month development schedule is assigned the utility of that lottery. The remaining intermediate utilities can be determined in a similar fashion as shown in Table 4. The decision maker's utility function can then be graphed as shown in Figure 4.

The utility function in Figure 4 for the weapons system procurement example has a concave shape which is characteristic of a decision maker that is risk averse (Goodwin & Wright, 2004). The utility function can now be applied to the decision tree in Figure 3 to determine the expected utility for each decision option as shown in Equations 2 and 3 and summarized in Figure 5.

$$(0.2 * 0.7) + (0.8 * 1.0) = 0.94 \quad \text{Equation 2}$$

$$(0.1 * 0.9) + (0.4 * 4.0) + (0.5 * 0.8) = 0.49 \quad \text{Equation 3}$$

Based on the expected utilities shown in Figure 5, weapon system 1 appears to be the preferred option due to its higher expected utility, but prior to making a decision, the decision maker should perform sensitivity analysis and consistency checks on the provided data. By varying the information provided by the decision maker in the elicitation session, the sensitivity of the calculated expected utilities for each option to changes in the supplied data can be determined and evaluated. Consistency checks

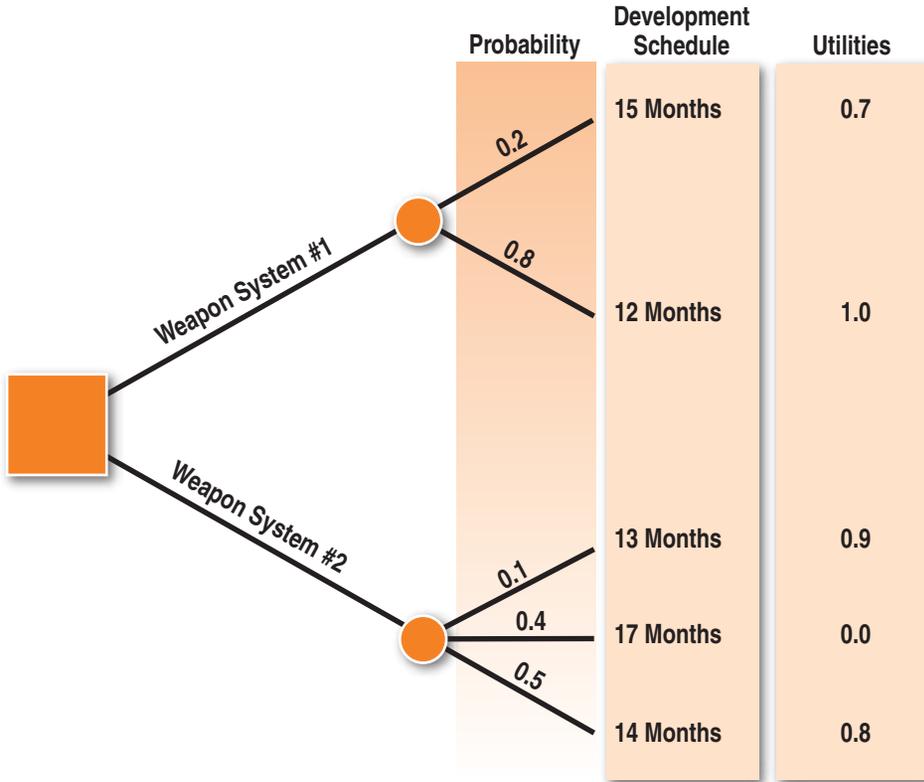


FIGURE 5. DECISION TREE SUMMARY FOR WEAPONS SYSTEM PROCUREMENT EXAMPLE

can determine if the utility function and calculated expected utilities accurately reflect the decision maker’s attitudes toward development schedule risk (Goodwin & Wright, 2004).

As shown in the weapons system procurement example, single attribute utility theory can be a valuable tool for the decision maker when faced with complex decisions involving uncertainty and risk. Multi-attribute utility theory can be utilized to extend single-attribute utility theory to problems involving multiple attributes. Keeney and Raiffa (1976) proposed the following approach to derive multi-attribute utility functions to allow a decision maker to evaluate problems involving risk, uncertainty, and multiple attributes. If mutual utility independence exists between the multiple attributes, the following three-stage process can be utilized to obtain the multi-attribute utility function (Goodwin & Wright, 2004):

1. Obtain the single-attribute utility functions for each independent attribute.

$$u(x_1, x_2) = (k_1 * u(x_1)) + (k_2 * u(x_2)) + (k_3 * u(x_1) * u(x_2)) \tag{Equation 4}$$

2. By using Equation 4, two single-attribute utility functions can be combined into a multi-attribute utility function (more than two single-attribute utility functions can also be combined into a multi-attribute utility function, but the equations are increasingly complex). In Equation 4, $u(x_1, x_2)$ is the multi-attribute utility level when attribute 1 has utility level x_1 and attribute 2 has utility level x_2 . The k_1 and k_2 values are employed to weight the single-attribute values and are evaluated in a similar fashion to the swing weights under SMARTS, except that lotteries are utilized. The decision maker is asked to choose between the following options:
- (a) A certain outcome where attribute 1 is at its best level and attribute 2 is at its worst level, or
 - (b) A lottery where there is a k_1 probability that both attributes will be at their best levels and a $(1 - k_1)$ probability that both attributes will be at their worst levels.

The decision maker is then asked to choose between the following options:

- (a) A certain outcome where attribute 2 is at its best level and attribute 1 is at its worst level, or
- (b) A lottery where there is a k_2 probability that both attributes will be at their best levels and a $(1 - k_2)$ probability that both attributes will be at their worst levels.

Equation 5 is then utilized to calculate k_3 .

$$k_3 = 1 - k_1 - k_2 \quad \text{Equation 5}$$

3. Complete consistency checks and sensitivity analysis on the multi-attribute utility function obtained in stage 2.

As was the case with SMARTS, the application of single- and multi-attribute utility theory can provide the decision maker with significant insights into complex decisions. The SMARTS, due primarily to its simplicity, can be an extremely valuable tool for employment in problems which do not involve uncertainty or risk. When uncertainty and risk are involved in a decision, as is often the case for Defense acquisition decisions, an understanding of single- and multi-attribute utility theory can also be a valuable asset to the acquisition decision maker.

OPERATIONS RESEARCH

The U.S. Department of Labor (2004) defines operations research as:

Operations research and management science are terms that are used interchangeably to describe the discipline of applying advanced analytical techniques to help make better decisions and to solve problems. The procedures of operations research have given effective assistance during wartime missions, such as deploying radar, searching for submarines, and getting supplies where they were most needed.

Wayne L. Winston (1994) provided a similar definition of operations research as “a scientific approach to decision making, which seeks to determine how best to design and operate a system, usually under conditions requiring the allocation of scarce resources,” and provided the seven step operations research analysis process shown in Figure 6.

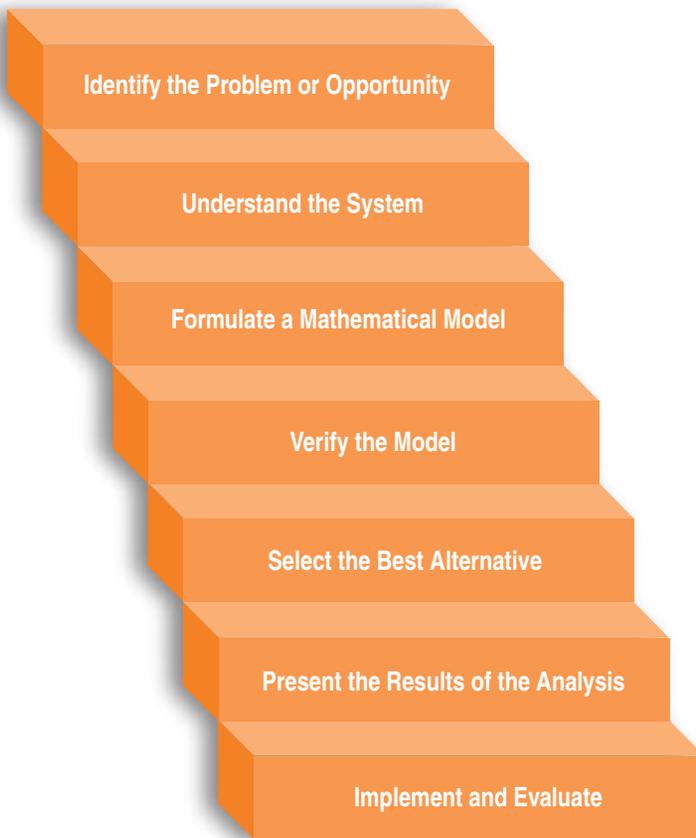


FIGURE 6. THE OPERATIONS RESEARCH ANALYSIS PROCESS (WINSTON, 1994; HARDIN, 2004)

As compared to the decision analysis process shown in Figure 1, which places a heavy emphasis on the subjective judgment of the decision maker, the operations research analysis process shown in Figure 6 places more emphasis on understanding the system, verifying the models, and formulating detailed mathematical models which incorporate risk profiles via probability distributions. A decision maker's subjective judgments, particularly those regarding risk, are not considered in operations research. As indicated by Dr. Richard Modjeski (2004):

Decision makers often are critical of Operation Research methods for ignoring subjective judgments. Personal judgments are a critical part of making good decisions in decision theory. Decision makers often site Operations Research for being precisely wrong instead of approximately right. This refers to the tendency to solve the wrong problem with the right method.

In some cases, decision makers may even reject mathematical models developed under operations research that have been optimized for the objectives of the overall organization if the decision makers' personal preferences, objectives, and attitudes towards risk do not completely coincide with those of the organization. An example may be an acquisition manager who chooses a procurement alternative that is low in risk versus an alternative with greater risk and potentially higher benefits to avoid being associated with a possible project failure.

By viewing a complex problem from both decision analysis and operations research perspectives, a manager can gain significant insight into a decision as the two methodologies for handling risk complement one another (Modjeski, 2004). By employing both decision analysis and operations research, a risk-averse acquisition manager may be able to better balance his/her tendencies towards rejecting a new innovative alternative with significant risk and the DoD's goal of exploring new opportunities and emerging technologies. Decision analysis may identify an acquisition manager's risk aversion and assist in developing risk-reduction alternatives (Goodwin & Wright, 2004); whereas operations research may identify how a high-risk project fits into the DoD's overall military acquisition strategy that mitigates risk across numerous research and development projects throughout the Defense Acquisition System. A manager who understands how to employ both decision analysis and operations research methodologies in complex decision making will be much better prepared to strike a successful balance between minimizing risk and maximizing opportunities.

CONCLUSION

Quality decision making is critical to the success of the Defense Acquisition System. The lives of U.S. Armed Forces members and those they protect often depend on the quality of Defense acquisition decisions. When faced with complex Defense acquisition decisions of high importance, decision makers should employ

compensatory, structured decision-making strategies to arrive at optimal courses of action versus heuristic strategies which provide only satisfactory solutions. Structured decision-making strategies, such as decision analysis and operations research can provide the decision maker with significant insight into Defense acquisition decisions. Application of multiple structured decision-making strategies can provide even greater insight by allowing the decision maker to view a decision from multiple perspectives as the strategies compliment one another. A decision-maker who takes the time to become proficient at applying multiple structured decision-making tools and strategies will be much better prepared to make quality Defense acquisition decisions, particularly when faced with complex decisions of high importance involving uncertainty, risk, and multiple objectives.



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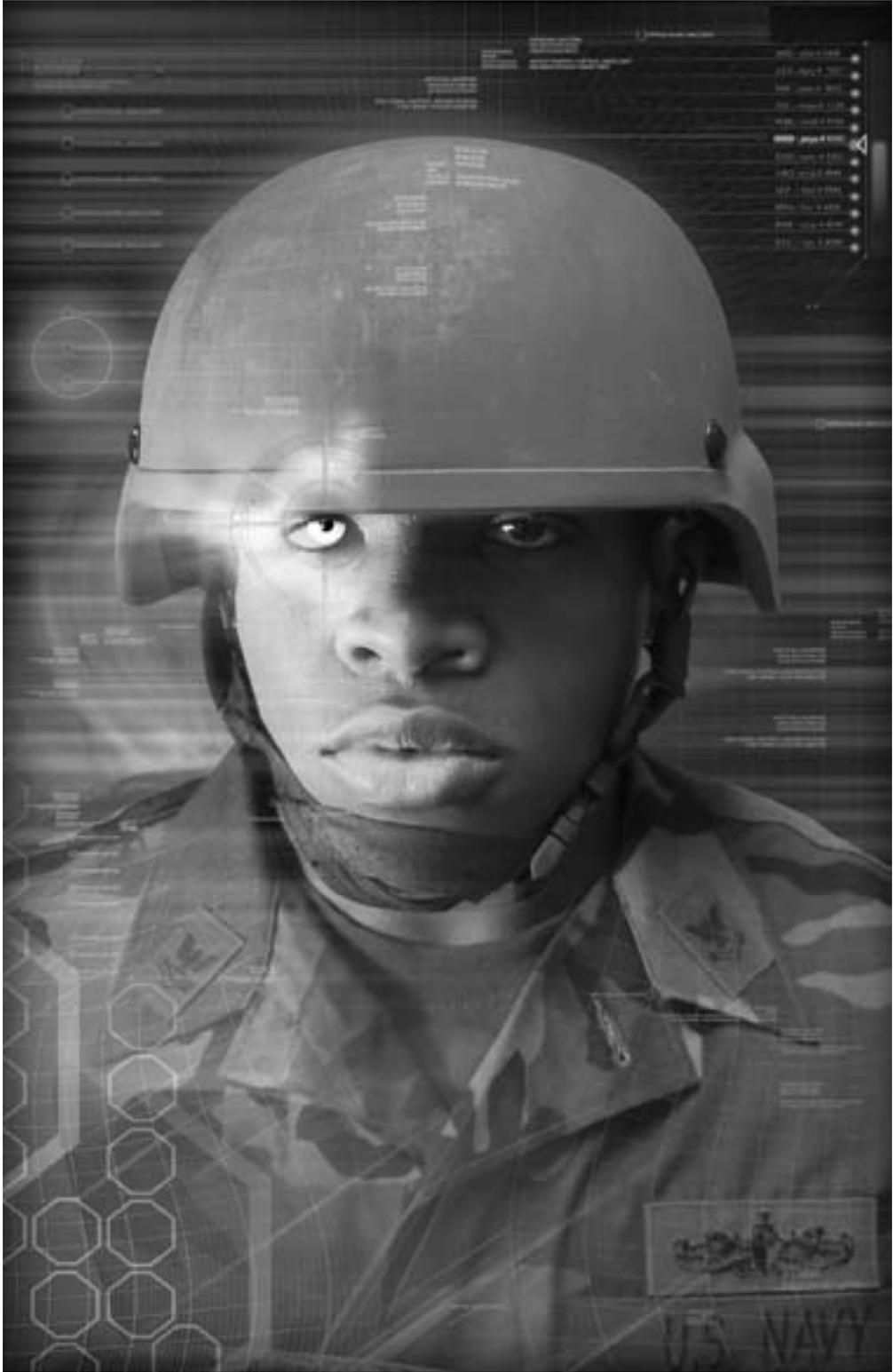


Image designed by TSgt James Smith, USAF

THE CHALLENGES AND OPPORTUNITIES OF IMPLEMENTING HUMAN SYSTEMS INTEGRATION INTO THE NAVY ACQUISITION PROCESS

James A. Pharmer

Over the last decade, the Department of Defense has placed increased emphasis on including considerations of human capabilities and limitations into systems engineering and acquisition processes. The purpose of this article is to provide an overview of how the Navy is implementing Human Systems Integration (HSI), the process of incorporating considerations, characteristics, capabilities, and limitations of human operators and maintainers within acquisition decision making at a level commensurate with decisions regarding hardware and software. More specifically, this article will address some of the policy initiatives, organizational changes, and implementation challenges of incorporating HSI into the acquisition life cycle to insure better total system performance and lower total ownership cost.

In the past, incorporating human considerations into the military systems acquisition process was often overridden by the need to deliver systems to the warfighter as quickly and inexpensively as possible. In fact, there were some major opponents to the ideas of bringing human factors into the fold. Perhaps the most outspoken of the critics was Admiral Hyman Rickover, who characterized the promulgation of a human factors program into the research, development, engineering, and production in shipbuilding as “about as useful as teaching your grandmother how to suck an egg” (1970). Since that time, however, several factors

have brought the need for considerations of human capabilities and limitations to light. Among these were (a) recommendations from a then-General Accounting Office (GAO) report, which cited human error rates as a key (in the range of 50 percent) factor in major system failures (GAO, 1981), (b) several very high-publicity military, industrial, and commercial aircraft accidents involving human error during the 1970s and 1980s, as well as (c) the recognition by the Department of Defense (DoD) of the impact of manpower costs on total system life cycle costs. Coupled together, these three factors have brought the necessity of considering human factors to the attention of the defense acquisition community. As a result, the consideration of human factors early in the acquisition process was mandated in the 1991 DoD5000.2 Instructions. Subsequent versions provided more and more detail on the component domains that must be considered in the acquisition process, including considerations of manpower, personnel, human factors engineering, habitability, safety, and health hazards. While the instructions have provided a springboard for inclusion of these factors into the acquisition process, the real work remains to be done to seamlessly integrate these considerations into the systems engineering framework so that human considerations have an equal footing with hardware and software considerations in the systems engineering process. Human systems integration (HSI) is the process by which this is accomplished.

The keyword in HSI is “integration,” which includes integration of human considerations into the systems engineering process as well as the integration of the domains within HSI.

The keyword in HSI is “integration,” which includes integration of human considerations into the systems engineering process as well as the integration of the domains within HSI. The old adage about giving a child a hammer and everything is a nail applies here. Experts in a specific domain tend to view the solutions to human performance issues to be within their own respective domain. For example, from the point of view of a training specialist, a human performance deficit will likely be viewed as a training problem with a training solution. However, from the point of view of a human factors engineer, the same problem may be viewed as a human factors design problem. Furthermore, from the point of view of a manpower analyst, the same problem may be viewed as a problem of allocation of tasks to an operator. In reality, human performance problems may have a number of solutions from each domain or, more likely, the solution may be a combination of solutions. As this illustrates, in addition to the need to integrate with non-HSI acquisition and systems engineering domains, there is a need for integration between the HSI domains to

collaborate effectively towards solutions to human performance issues within the context of cost and schedule constraints.

While the implementation of HSI is a challenge for all branches within DoD, the purpose of this article is to provide an overview of the work that the Navy specifically has undertaken on these challenges with respect to changes in policy and organization, as well as the issues of implementation that are faced by major acquisition programs in terms of organization, planning, and conducting analyses.

POLICY

The mandate for HSI within the DoD 5000 series brought considerable attention to the need for this process to be a part of the larger acquisition process at all levels. Among the biggest supporters of this effort was Admiral Vern Clark, the Chief of Naval Operations (CNO) at the time that the latest version of the 5000 series was promulgated. Under his direction, the relevant Offices of the Chief of Naval Operations (OPNAV) and the major systems commands for Surface (SYSCOMs)—Naval Sea Systems Command (NAVSEA), Aviation—Naval Air Systems Command (NAVAIR), and the Space and Naval Warfare Systems Command (SPAWAR) were tasked to develop plans to insure that HSI was a part of current acquisition programs. The current CNO, Admiral Mike Mullen, has persisted in supporting these policies and OPNAV organizations have set about the development of policy, instructions, and guidance to accommodate the emphasis on HSI including extensive work to map analyses, processes, and deliverables required for HSI to align more readily with the systems engineering and acquisition frameworks. This will insure that outputs from the HSI domains interleave with current milestones and phases in a manner that allows for a real impact on design decision-making trade-offs. Among the major Navy initiatives is the development of the Systems Engineering, Acquisition, and Personnel Integration (SEAPRINT) effort, the goals of which are to standardize Navy HSI policy, ensure HSI issues are addressed, and to facilitate HSI analyses. The SEAPRINT is a Naval Enterprise-wide approach, which includes seven actionable tenets for the implementation. These are: (a) initiating HSI early in the acquisition process, (b) identifying HSI issues and planning analyses to mitigate these issues, (c) insuring that HSI is “crosswalked” throughout relevant acquisition documentation, (d) making HSI processes a factor in source selection, (e) execution of an integrated technical process, (f) conducting proactive trade-offs within the acquisition process, and (g) conducting HSI milestone assessments. A more detailed discussion of SEAPRINT is beyond the scope of this article. For more information on this initiative please refer to the Navy Human Performance Center website at https://www.spider.hpc.navy.mil/index.cfm?RID=WEB_OT_1001399

ORGANIZATION

The major SYSCOMs of the Navy, responsible for developing and acquiring systems to support the warfighters, each had unique challenges given large

differences in organizational structures and business processes. For example, NAVSEA was able to establish an HSI directorate (NAVSEA 03) within their organization, sanctioned with technical authority to review the status of HSI performance within new acquisitions, as well as to upgrade and to modify legacy programs within an organizational structure heavily centered on specific surface activities and warfare systems.

The NAVAIR organization is based on the systems engineering competencies required to develop aircraft and related weapons systems. In other words, there is a competency for logistics, a competency for program management, a competency for science and engineering, etc. Personnel are pulled from each of these competencies directly to support any given acquisition program. As such, responsibility for specific HSI products are spread throughout the organization and ownership of these processes may fall within several competencies. The NAVAIR approach was to (a) institute HSI measures within its Systems Engineering Technical Review (SETR) process rather than develop a specific directorate charged with HSI review and, (b) to realign specific competencies related to human performance science and technology to provide expertise and support to individual programs through Integrated Product Teams (IPTs) participation.

The NAVAIR organization is based on the systems engineering competencies required to develop aircraft and related weapons systems.

There was a danger, however, in having each of the Navy SYSCOMs developing unique HSI processes and organizations in isolation. Without close coordination between the SYSCOMs, it was possible, in fact likely, that each would develop its own unique ways of doing business. Given the complexities of network-centric warfare, the necessities of interoperability, and the tight coupling and integration between systems required in today's warfare, these unique approaches would likely result in untenable mismatches that would have serious consequences to cost and schedules of acquisition programs, especially those where integration of air and ship operations are vital. Consequently, the Navy's SYSCOMs have worked together within a "Virtual SYSCOM" to insure that policies and processes do not diverge. Thus, representatives from the "Virtual SYSCOM" have collaborated extensively on the development of guidance for program management and development of metrics for human performance, technical (i.e., programmatic) performance, and common HSI processes. Further, the CNO provided funding for the Human Systems Performance Analysis Capability (HS-PAC) effort to develop an infrastructure to support the distribution of data relevant to human performance, thereby fostering the integration of research, development, and fleet operational activities.

EDUCATION

The implementation of HSI into the acquisition and systems engineering processes would have little likelihood of success without some effort to educate the workforce on the processes involved. As such, each of the SYSCOMs has put significant effort toward this task. Early on, these efforts focused on educating a wide range of individuals, from technical directors and program managers to systems engineers to scientists and engineers within specific HSI disciplines (e.g., Human Factors Engineering, Manpower, Personnel, Training, etc.), on basic to advanced topics in HSI. In part, as a result of these initiatives, universities and colleges are beginning to offer degrees and certificates in HSI as well. In fact, the Naval Postgraduate School now offers a graduate degree in HSI to its students.

IMPLEMENTATION

The major challenges with the implementation of HSI have been within acquisition programs themselves because, to some degree, a cultural change has been required to more fully integrate the disciplines of HSI into well established systems engineering and acquisition activities. A number of factors have come into play on how successfully HSI can be integrated into these processes, not least of which is acceptance of the value of HSI by program management and communication of this acceptance throughout the program. Other significant factors include considerations of the current acquisition phase (earlier is better to be most effective) as well as more typical concerns of funding profile, schedule constraints, and trade space (e.g., legacy equipment/new design). The following sections will discuss some of the major challenges to the development of requirements for HSI, planning to meet those requirements within the acquisition schedule, as well as conducting the analyses necessary to meet opportunities to insure high levels of human performance (and the resultant system performance) and operator situational awareness while maintaining manageable workload levels.

HUMAN PERFORMANCE REQUIREMENTS

One particularly challenging aspect of implementing HSI within an acquisition program is that the science that guides human performance is relatively new in comparison to the physical sciences, and much more subject to individual variation. Thus, the development of requirements and associated metrics that can be monitored and traced across the acquisition life cycle is difficult. This is especially true for such human constructs as situational awareness, workload, and fatigue, which have both physical and cognitive components. The challenge is in developing high-level requirements in early requirements document that can be traced and monitored from early concept exploration and refinement to sustainment and disposal of the system. Workload, for example, can be thought of as the ratio of tasks to the time to

complete them. However, it can also be considered to include such cognitive factors as frustration and cognitive effort. Thus, wide latitude of interpretation could be made with a requirement to reduce workload unless tied to a very specific and testable definition provided in the requirements.

One approach that has met with a great deal of success within the DDG1000 (formerly DD[X]) ship program was to use manning levels as a Key Performance Parameter (KPP) in the Operational Requirements Document (ORD). In the case of this program, the threshold value of this KPP represented a significant challenge to designers that could most likely only be met through innovative design to support fewer operators performing a much broader mission, without sacrificing operator situational awareness or substantially increasing workload. However, while this manpower KPP has worked well in the case of DDG1000, it is by no means a panacea to be applied by other programs as a substitute for careful requirements and function analyses. In this particular case, the manpower KPP provided a useful tool for developing metrics to measure the impacts of design decisions against the risk of manpower increase, which may work well within a program focused on a total ship but would probably have less utility for smaller craft and/or weapons system. The bottom line is that the qualities of metrics within HSI are no different than those usually tracked within an acquisition programs. They should be chosen based on their validity, reliability, relevance to the unique issues of the mission, and should be directly tied to cost, schedule, and performance parameters of concern.

THE HSI PRODUCT TEAM

Generally, most programs have integrated HSI by implementing IPTs, or in some cases, Cross Product Team (CPT) structures, into their processes. And, as with any other IPT or CPT within a program, success is dependent on such factors as leadership, empowerment, and having the right skill mix to do the job. Perhaps at least as essential to the success of these teams is external integration with the relevant “non-HSI” disciplines. The best and brightest ideas generated within the IPT are of no value if they are not communicated effectively to program management, engineering, and design disciplines outside of the team. Thus, program management support and communication of that support throughout the program are essential to the success of HSI. If other organizations and individuals within the program view HSI as purely an academic exercise, then value related to better designed systems and decreased total ownership cost will not be likely to be realized.

THE HSI PLAN

Another key to the success is the development of a HSI plan that includes not only the goals and visions for HSI, but which also provides a process and schedule, which aligns closely to the larger program reviews, milestones, and deliverables. Without this alignment, opportunities for making a human performance impact to the design are greatly reduced, being overcome by acquisition events and design decisions already made without the benefit of HSI input. Again, the need for good communication external to the HSI IPT is important. Allied with this issue, however,

is the necessity that acquisition programs allow time and funding to allow for human performance analyses and trade studies to be conducted within sufficient time to make these impacts. Thus, while it is essential that the HSI plan align with the acquisition schedule, it is also important to have the support of the program and an understanding that the dividends of designing for the sailor will pay off in total ownership cost, less rework, and higher total system (i.e., hardware, software, and human) performance.

HSI ANALYSES

Ultimately, the goal of HSI is to integrate considerations of human capabilities and limitations into the design decision-making process already being utilized for hardware and software. Integration of HSI analysis into the acquisition and systems engineering process is the key to achieving this goal. Just as it is prudent and necessary to perform analyses, testing, and verification for software and hardware integration, these same activities are required for integrating the human operator into the system. The following discussion describes some of the analysis activities that can assist in insuring that this integration takes place.

Ultimately, the goal of HSI is to integrate considerations of human capabilities and limitations into the design decision-making process already being utilized for hardware and software.

Top-Down Function Analysis (TDFA) is a family of systematic analyses and resulting documents that decompose the mission of an emerging system in a manner that links hardware, software, and human performance requirements to the intended mission (Bardine, Goff, & Wilson, 2003; Wallace, Winters, Dugger, & Lackie, 2001; Gordon, Burns, Sheehan, Ricci, & Pharmed, 2005). An excellent example of TDFA was conducted within the Multi-Mission Maritime Aircraft (MMA) program (Gordon, Burns, Ricci, & Ramsden, 2005). The primary purpose of this TDFA was to determine specific areas on which to focus training development. However, the data within this analysis have value to support human engineering decisions on what specific tasks and functions may require design support as well (e.g., decision aids, display and control, automation, etc.). Further, these data could support decision making related to manpower and the allocation of tasks/functions to operators and maintainers. The utility of such an approach is that the data can be shared across HSI domains to provide a common framework from which to make engineering decisions.

The DDG1000 program has had a great deal of success in insuring a tight integration between the HSI CPT activities and system engineering activities

within the program through the Mission System Design Analysis (MSDA) process. These analyses represent operators and maintainers within the context of mission performance providing a means of expressing functions and capabilities explicitly across hardware, software, and human aspects of the design (Wallace & McKneely, 2006).

Both the MMA TDFA process and the DDG1000 MSDA process are good examples of large-scale Navy programs implementing analysis techniques that provide opportunities for dialog between systems engineering and HSI disciplines. However, these activities have had equally important benefits that go beyond strengthening coordination and communication within their respective acquisition programs. The activities have also provided unique opportunities for these programs to regularly interface directly with fleet subject matter experts (SMEs). Through the interaction with individuals who are experts in the military domains, designers and developers of the systems to support these domains have gained a better understanding of their intricacies and complexities, thereby increasing the probability that the systems that are delivered meet the true requirements of the operators and maintainers. Most HSI professionals would agree that more is better when it comes to these interactions.

A critical component of HSI is to conduct human factors engineering analyses focused on the usability of human system interfaces. Ideally, these activities are conducted iteratively throughout the acquisition life cycle.

As these programs have continued to progress beyond function and task analysis activities, the interaction with the fleet becomes more and more important. As such, a critical component of HSI is to conduct human factors engineering analyses focused on the usability of human system interfaces. Ideally, these activities are conducted iteratively throughout the acquisition life cycle. In the initial stages of a design concept, human factors engineers actively participate in the design process regularly conducting such activities as heuristic evaluations (i.e., usability analysis utilizing “rules of thumb” of good human factors design) and audits to insure compliance with human engineering standards and guidelines. Warfighter feedback is actively sought in these stages through activities such as focus groups where design concepts are storyboarded and presented for review and comment. During these activities, SMEs may be asked to cognitively walk through scenarios and procedures to identify potential usability issues related to workload, errors, and situational awareness.

Like the function analytic activities described above, heuristic evaluation, standards compliance audits, focus groups, and cognitive walkthroughs have had the benefits of

allowing a better understanding of the domain, the opportunity for direct warfighter involvement in the design process and, perhaps most importantly, the opportunity to identify potential usability issues early enough in the design process, to make an impact before design changes are prohibited by cost and schedule concerns. As the design concept matures, usability testing may be conducted iteratively by using interactive prototypes and, ultimately, operational systems to continue to identify usability issues and to determine whether the issues identified represent system (i.e., hardware, software, and/or human) performance issues that must be addressed.

While warfighter interaction is essential to HSI, programs have had several challenges to taking this approach. First, active duty fleet personnel with the needed knowledge, skills, and abilities for a particular domain, especially newly conceptualized domains, are rarely in endless supply and must balance their time between their “day job” and assisting in the development of future systems. Thus, many times, there are simply not enough qualified participants available to conduct test and assessment able to conclusively support design decisions. Second, humans-in-the-loop data are often difficult to analyze and interpret in a timely manner, especially for highly complex systems and warfare domains. Third, a number of design issues focus on extremely hazardous activities where ethical considerations would prohibit or limit the ability to conduct human in the loop evaluations.

HUMAN PERFORMANCE MODELING

Over the last decade, the Office of Naval Research (ONR) has funded a number of programs focused on human performance modeling, the representation of certain aspects of human behavior in a form that allows for simulation-based prediction (Campbell, et al., 2002), as technologies that may have the potential to mitigate some of these issues. One research thrust of the ONR-sponsored Manning Affordability Initiative (MAI) was to investigate the potential for human performance modeling applications to design teams with the ability to more rapidly conduct design trade-off activities and provide opportunities to manipulate projected operator-system interactions in an often more cost effective manner than humans-in-the-loop studies. The modeling research and development within MAI were primarily focused on investigating how human performance modeling could support human-centered design to realize manning reduction on future naval surface combatants. More specifically, the design trade space utilized for this research program centered on the development of a human-centered design console to support manning reduction within the Air Defense Warfare (ADW) suite of a combat information center. Human performance modeling efforts were conducted within this program to perform design trade-offs on console design, the flow of operator tasks, and the allocation of tasks to operators.

In addition, the effort investigated techniques for increasing the fidelity of models by verifying model predictions with data collected in a humans-in-the-loop study using current operators executing a realistic and challenging ADW scenario on prototype consoles (Scott-Nash, Carolan, Humerick, Lorenzen, & Pharmer, 2000). The results of these investigations demonstrated the potential value of utilizing human performance modeling techniques to provide the engineers with a structured

method of quantifying differences in human performance between alternative designs. Human performance modeling techniques may have the potential to help resolve some of these issues and are being embraced by the acquisition community.

Examples of human modeling techniques currently being utilized by systems designers include anthropometric, cognitive process, and task network modeling. Anthropometric modeling focuses on the physical attributes of the projected user, by replicating them into 3-D graphical figures in order to provide systems designers with realistic ideas on how conditions, objects, and tasks associated with the planned environment may impact the human operator. There are a number of cognitive process models, which, as their name implies, function to simulate some aspect or aspects of human cognitive activity. For example, some cognitive models have been developed to function as interface evaluation tools by taking characteristics of the task and interface into account with research established on human capabilities and limitations in regard to perception, cognition, and motor processing to model interactions between the human operators and their systems (Campbell et al., 2002). These simulations can provide system designers with a great deal of insight related to human interface interaction, thus allowing for realistic performance predictions (Zachary, Campbell, Laughery, & Glenn, 1998). Timing and accuracy data associated with the planned work environment can be obtained by utilizing task network models, which are discrete event simulations based on detailed task requirement data (Laughery & Corker, 1997). If properly incorporated within the test and evaluation phase of system design, human performance models can provide assistance in both design assessment and validation.

CONCLUSION

As is hopefully evident from the discussions in the preceding sections, it is clear that the Navy has placed a great deal of emphasis on designing systems with operators and maintainers in mind. As initiatives in organizational structure, policy, process, and education continue to take hold, it is expected that the increased attention to these systems will pay dividends in terms of better total system performance at a lower total ownership cost.



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Image adjusted by TSgt James Smith, USAF

APPLYING OFFICE LEADERSHIP SOLUTIONS TO MANAGEMENT RECOMMENDATIONS IN SOLVING ACQUISITION PROBLEMS

Martin Cain

Leadership is the process by which high-performance acquisition takes place. Influences on management as a result from inspections such as internal auditing can pull attention from long-term leadership goals. This article researched the nonquantifiable impacts from internal auditing and compared them to effective leadership principles. Conclusions indicated that management could make better use of audit recommendations by applying leadership to actions in solving problems and implementing change.

Management recommendations resulting from audits or inspections calling for corrections in behavior from leaders and those they lead can bring about a change in culture and attitudes that may or may not be consistent with overall long-term goals and objectives of achieving excellence. Solving problems brought up in audit reports, for example, have the potential to influence a manager's behavior to act in a manner to satisfy the recommendations to solve problems and make improvements. The incentives to comply with inspector recommendations ought to be congruent with the leader's desire to earn the trust and cooperation from others and be free to take risks when the potential benefits can justify the actions. In order for leaders to understand and work within the organizational culture they require an awareness of the perceptions resulting from administrative actions that influence relationships. One study suggested that for best results, leaders should understand

their subordinates enough to predict the outcomes from their actions and get the intended outcomes (Anderson, 1998). Not knowing the outcomes from an audit inspection could decrease effective results from leadership in the office.

METHODS

Consequently, this article focuses on the nonquantifiable implications from management recommendations primarily resulting from audit reports. Data were derived from a research study exploring leader perceptions to internal auditing, and the principles gained have application to solving acquisition problems as well as commercial and other governmental organizations with an internal audit function. The conclusions expressed here relate to the identification of leadership outcomes from the author's research study conducted for a doctoral dissertation for the University of Phoenix. The research included 30 interviews with leaders and an analysis of 10 major audit reports published between 2000 and 2004.

FINDINGS

Audits and inspections generate management movement within an organization as management attempts to solve problems before, during, and after the inspections. Not only are the economic and financial factors impacted, but nonquantifiable factors relating to human relations are also put into motion. Information presented here follows two principles: (a) Audit influences are qualitative as well as quantitative, and (b) Leadership skills are needed to address audit recommendations to management from a qualitative perspective of human relations. Leadership skills are detailed into areas of empowerment, management actions, trust and risk taking, and potential leadership benefits from auditing.

An audit report could possibly either encourage systems thinking and long-range leadership principles, or encourage short-term management reporting that may not be consistent with the leadership objectives. Influences of leadership are often qualitative and long term. Management influences are often quantitative and short term. Softer principles of leadership are difficult to quantify and include principles such as: acting honestly, being visionary, modeling behavior, listening empathically, displaying kindness, and using long-range system thinking. Management, on the other hand, measures productivity, profits, expenses, and time in short periods such as quarterly or annually. The focus on reporting of short-term results could detract from long-range leadership goals and objectives that are not measured as accurately or frequently (*Federal Times*, 2003b). The influence on management from an internal audit report could be adjusted to help align this quality resource to long-term leadership objectives.

INTERNAL AUDITS AND THE LEADERSHIP CONNECTION

The value of an internal audit may be distorted if the value is solely based on quantitative data in an audit report and not the impact on human relations within the culture of an organization (Schein, 1997). The author's research indicated nonquantifiable implications from audit vibrations included impacts on fear, stress, tension, motivation, management behavior, and the perceived quality of the workforce. The motivation of followers and leaders is impacted by tension and fatigue that result from the inspection process (Cooper & Sawaf, 1997). An understanding of both quantitative and nonquantitative aspects from an audit could help leaders make informed decisions and better understand the influence of their actions.

Internal audit reports have an influence on the actions leaders take to prepare for an audit and comply with audit recommendations.

Internal audit reports have an influence on the actions leaders take to prepare for an audit and comply with audit recommendations. For example, if internal auditors identify a potential to save \$850 million, then management would be required to take actions to achieve the predicted results. Responses to the audit would require management to use leadership skills to motivate others to comply with changes and achieve the desired savings. A lack of leadership skills in forcing change could result in negative outcomes. The nonquantifiable outcomes generated from management responses to an audit could throw an organization off balance, force managers to be preoccupied with audit processes, and distract from essential leadership objectives of inspiring others to change (Strathern, 2000). Management actions should also be consistent with efforts to improve or maintain effectiveness and efficiency.

Leadership skills are needed to improve the problem-solving effort. In order to improve effectiveness and efficiency, management must respond to recommendations with actions that will not only improve the inspection process, but result in effective leadership. By its nature, an audit tends to focus on attributes and factors that are quantifiable. The audit process also serves as a catalyst that generates numerous outcomes that are not quantifiable and impact team and individual performance. Those outcomes may impact organizational culture and levels of trust in leaders. For example, an audit resulting in additional controls over executive travel expenses could create a change in the culture of leadership and perceived level of trust from subordinates and top management. A change in management can come as a result of the findings and recommendations in an audit report.

The findings and recommendations of audit reports have an influence on the behavior of management and the perceptions of their abilities and intents to establish

trust, take appropriate risks, solve problems, and cope with change. An audit often finds discrepancies and faults of management, and the process tends to encourage management to take corrective actions and comply with policies years after an audit is completed. When significant discrepancies are reported through an audit, management can respond with a plan of action to solve the problem. The scrutinizing of management actions can impact the cultural environment and influence perceptions of such qualitative factors as trust from subordinates and limitations on the extent of risk taking that management is willing to allow. Low trust can lead to low collaboration and weaken group effectiveness that could impact the mission of the organization (Clegg & Hardy, 2002).

To recruit and retain quality people managers need to perform as leaders in a manner that models the behavior they seek. The leadership culture requires attention to various aspects of leadership. A survey conducted by Kunich and Lester (2003) reported the number one concern about leadership was ineffective communication. Another big concern was inappropriate goal setting (p. 108). Effective communication should include empathic listening to understand one another and improve group cohesiveness. Inappropriate goal setting may involve goals derived from audit actions that could be misaligned with overall long-term objectives. The organization's structure, processes, and systems should be aligned with the mission and not compete with it or dominate it (Block, 1995).

COMMON PERCEPTIONS OF AUDIT OUTCOMES

An understanding of the perceptions of audit outcomes could provide insight into how well management models the behavior they seek, how well they listen to subordinates, how well subordinates communicate their perceptions to management, and how well the goals and actions from auditing are aligned with organizational objectives. Many influences compete for the attention of leadership. Finding the right formula for successful leadership is a constant challenge. In short, understanding the perceptions of auditing outcomes could aid in the development and growth of people. Managers can more effectively utilize the audit function through their leadership approach to empowering subordinates, managing actions in resolving audit issues, and building trust while encouraging risk taking. Each of these approaches could lead to potential leadership benefits from auditing.

The perceptions from auditing could impact the way managers empower others and promote trust and appropriate risk taking. A major part of leadership is "growing people" by empowering others and giving them training and learning opportunities to broaden their perspectives and abilities (Weber, 1996). As people are developed through empowerment, the culture of trust is impacted. Trust and appropriate risk taking are part of the qualitative culture of leadership. Subordinates need to trust the leaders to be fair and have the best interest of the organization and society as a priority. Of necessity, leaders and empowered subordinates need to be encouraged to take appropriate risk in being innovative in finding solutions to tough problems and encouraging the same in others. Leaders will have a greater insight into how to add value to people when they understand the thoughts and feelings of the people they serve. A lack of success could have serious consequences in accomplishing the

mission of the organization. Since leaders need to comply with laws, the findings in audit reports identifying leaders either complying or not complying with laws and rules could impact the image of leadership by the subordinates and consequently impact trust (Kunich & Lester, 2003). Research into leadership perceptions of auditing could impact organizational performance through understanding of how well trust is developed.

Since management of materials and processes in an audit can impact the leading of people, management actions taken as a result of an audit could influence the perception of leadership (Bennis, 2002). Attitudes and perceptions of leadership impact retention, morale, productivity, and dedication, which are all essential for a healthy organization (Katz & Kahn, 1978). Michael Quinn Patton (2002) provided an example of the need to focus on more than just the quantifiable outcomes of an audit. An audit may place “too much emphasis on things that can be quantified so that it misses the results . . . that are not easily measured” (p. 18). Examples of those difficult-to-measure outcomes in Patton’s example were anxiety, low trust, and an undesirable atmosphere at work.

RESPONSES TO AUDIT RECOMMENDATIONS

In responding to audit recommendations, management could be responsible for actions to improve fiscal economies, managerial controls, and logistical outcomes. These managerial actions are designed to provide better policies, structures, and processes to more efficiently utilize resources to achieve effective outcomes (Drucker, 1999). Actions involving saving money or strengthening controls for better long-range outcomes also impact the people that carry out those actions. The statements and actions of the managers simultaneously affect the image and identity of the organization (Hatch & Schultz, 1997). Audit actions then in theory could contribute to the identity and image of the organization that could impact perceptions that influence trust.

A lack of trust could be motivated by leader managers not modeling the behavior they desire in others or giving directions that are inconsistent. Major motivators of management actions are internal audit reports that not only report on the effectiveness of management’s actions, but also give recommendations and record actions taken, or to be taken, by management to improve operations. The perceptions of subordinates on those actions may be a hidden factor that is not part of the decision criteria.

A lack of appropriate risk taking could be related to management actions of not empowering subordinates or requiring compliance to internal controls that may be tied to short-term quantifiable measures rather than long-term or qualitative factors. Again, this condition is related to leadership and could also be interrelated with action involving an audit. Semler (1995) reported that he removed many policy manuals from his company (Semco) and relied on his managers to make good decisions that impacted their stewardship. This nonquantifiable control of trust resulted in a better control than the measured controls that existed in policy manuals designed to maintain order. The overall long-term outcome of the nonquantifiable controls resulted in survival and profits for the company when competitors were

losing profits. Empowering subordinates is just one management resource that could be impacted by an audit report.

The culture can be manifested in the roles people play. Under the leader-role theory described by Bass (1990), “Leaders behave according to what is expected of them” (p. 44). If the image of the organization defines the leader’s role as one that takes immediate and decisive action to solve a problem, the actions help form attitudes and perceptions. The same principle could be applied to followers if they in turn would behave according to what is expected of them. Thus the transformational role of leaders may be acted out without conscience direction of the implications from the roles played (Couto, 1995). The role of an authoritarian leader could produce one result, and the role of democratic leader could produce another. Those results are a manifestation of the changes initiated by the leaders using the culture of the organization.

Understanding, learning, and morale are all essential ingredients for improved leadership. Leaders cannot get followers to understand them, until the leaders understand the followers. As Kunich and Lester (2003) put it, “Leaders need to know and understand their subordinates” (p. 42).

IDENTIFYING THE AUDIT FUNCTION

The audit function can either focus on policing efforts for management or emphasize learning and consulting. Although an audit may conduct studies to assess compliance with laws, policies, and regulations, an audit can also act as feedback to improve effectiveness of operations. Auditing should support every level of management with middle managers the prime customers in a stewardship environment to give high-performance potential to human resource policies (Block, 1995).

The morale and emotional well being of subordinates determine the effectiveness of operations and should be a major emphasis of the audit function (Block, 1995, p. 147). When top management is the primary customer of auditing, it gives the appearance that auditors act as the eyes, ears, and voice of top management and creates a “separation between those who do the work and those that manage the work” (Block, p. 117). The Government Accountability Office and its standards are an example of “policing in the name of help” (Block, p. 119).

Audits stimulate change. Kanter (2000) recognized the need for involvement to get people to change. Leadership is required to create the involvement to lower the resistance to change. Wren (1995) noticed that resistance builds when trying to force people to analyze assumptions in their work. Actions forced on people from auditing can also create an equal amount of resistance or compliance depending on the participation and involvement of those required to change. Chris Argyris was quoted by Bass (1990) as saying, “An organization will be most effective when its leadership provides the means whereby followers may make a creative contribution to it as a natural outgrowth of their needs for growth, self-expression, and maturity” (p. 43). Followers of auditing outcomes may also make creative contributions to resolve audit findings and be enthused about the improvement process. Participative leadership suggests leaders create the conditions for members of the group to feel free to

actively solve problems (Bass, 1990, p. 437). Understanding and effective leadership can overcome much resistance to change and the related cultural values.

The strategies used to fix problems in the present should not be structured to set off a chain of events that will require more attention and resources in the future (Oliver, 2002). Cause and effect are separated by time and space and the effect of changes may not happen for a long time after the changes are made. Senge (1994) cautioned against short-term fixes which only appear to make problems go away. The effects of some actions may not appear for years, giving management the impression that the short-term fix was effective. Watered-down compromises that reflect murky assumptions could be full of contradictions that decrease trust and support from subordinates who are left to face the effects of management actions.

THE KEY ROLE OF LEADERSHIP

Leadership is the process by which effective management takes place. For example, Senge (1994) warned that the process of emphasizing financial accounting as the only system to deal with neglects the dynamic complexity of the conditions that create the accounting reports. By the same principles, an audit that focuses only on financial or economic systems may neglect the long-term impact from the soft systems that manage the accounting systems.

***Leadership is the process by which
effective management takes place.***

The human side of systems thinking increases understanding of the humans involved and the corporate culture in which they operate. The culture, attitudes, and assumptions of the followers will impact the way they perceive the leaders. The integrity, discipline, and desires of the followers will determine what they consider important. If the goal of a worker is to gain material goods through the easiest route, the behavior may reflect the attitude. If the goal of the worker is personal mastery and growth, the behavior could be significantly different.

The soft systems may be hard to quantify. Senge (1994) wrote, “No one will ever be able to measure to three decimal places how much personal mastery contributes to productivity and the bottom line” (p. 146). He defines personal mastery as the discipline to clarify personal vision and as seeing reality objectively (p. 7).

Likewise, the nonquantifiable outcomes from leadership may not be tied directly to profits, but all outcomes have an impact. Actions that take away from subordinates’ desires for personal mastery and growth could be detrimental to exceptional productivity. Actions that transform people into better people are results of positive leadership outcomes. Sensitive leaders need to cultivate the true dedication and

innovation from subordinates who are part of the complex soft systems involving organizations and the nonquantifiable leadership perceptions and outcomes from auditing.

RECOMMENDATIONS

The research exploration of nonquantifiable leadership perceptions supports the following recommendations for management to either do or continue to do as they strive for excellence and high performance.

1. Managers closer to audit findings should resolve the issues using knowledge of the culture and audit perceptions to guide their decisions.
2. Management responses to auditing should take the emotional well being of their people into consideration when giving directions that result from audit recommendations.
3. Management should raise awareness of the perceptions of the policing aspect of their actions and adjust actions to compensate for those perceptions.
4. Organizational management should be aware of problem-solving outcomes in order to be a step closer in the progress to a high-performance organization rather than a high-compliance organization.
5. The internal audit focus should expand to serve management with suggestions on how their leadership could be improved.
6. Internal auditing should expand to include recommendations based on human resources and relationships rather than economics to improve the success rate of implementing changes.
7. Auditing and management should address the leadership methods through an open system recognizing multiple influences, including the soft systems of human interrelations.
8. Management should bring in a systems-thinking approach when responding to an audit to include the soft systems of the human activities (Checkland, 2001).

While implications from the above recommendations would be positive, resources would still be required to expand the use of auditing and apply additional understanding and knowledge to making changes. The investment in this effort should be worth the effort in the long term as the organization runs more efficiently and effectively to perform its mission.

SUMMARY

The exploration of the perceptions of leaders influenced by auditing indicated management concepts of structure and control were emphasized at the expense of leadership concepts of human relations. The management functions of auditing and strengthening internal controls were separated from the leadership role of understanding human emotions and effectively motivating followers to make changes. While auditing is a management tool, the activity should be combined with leadership roles to fully benefit from auditing. A leadership focus in the audit process as a cause of either positive or negative findings could be a method of integrating management with the leadership role and becoming more effective at both managing and leading. Also, a leadership emphasis in taking management action and implementing changes to solve problems could make the effort more effective in leading people and creating the conditions for them to be productive. People and organizations win when leadership skills are applied to management actions on audit recommendations. Effective problem solving in acquisition will only take place through an effective leadership process.



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