2010-04-30

US Space Acquisition Policy: A Decline in Leadership

Borst, Barry "Jay"

http://hdl.handle.net/10945/33487

NPS-AM-10-054

EXCERPT FROM THE
PROCEEDINGS

OF THE

SEVENTH ANNUAL ACQUISITION RESEARCH SYMPOSIUM
THURSDAY SESSIONS
VOLUME II

Acquisition Research
Creating Synergy for Informed Change
May 12 - 13, 2010

Published: 30 April 2010

Prepared for: Naval Postgraduate School, Monterey, California 93943

The research presented at the symposium was supported by the Acquisition Chair of the Graduate School of Business & Public Policy at the Naval Postgraduate School.

To request Defense Acquisition Research or to become a research sponsor, please contact:

NPS Acquisition Research Program
Attn: James B. Greene, RADM, USN, (Ret.)
Acquisition Chair
Graduate School of Business and Public Policy
Naval Postgraduate School
555 Dyer Road, Room 332
Monterey, CA 93943-5103
Tel: (831) 656-2092
Fax: (831) 656-2253
E-mail: jbgreene@nps.edu

Copies of the Acquisition Sponsored Research Reports may be printed from our website www.acquisitionresearch.net

US Space Acquisition Policy: A Decline in Leadership

Barry "Jay" Borst—Jay Borst is a PhD student in systems engineering at the George Washington University. His current research interests include acquisition policy and innovation. He currently works at the National Reconnaissance Organization.

Shahram Sarkani – Professor Shahram Sarkani has been engaged in engineering research, technology development, and engineering education since 1980. The author of over one hundred technical publications and presentations, Professor Sarkani focuses his research on the study of how such natural forces such as earthquakes affect buildings, bridges, and other human-made structures. His main research interests are structural failure—with emphasis on structures subjected to dynamic and cyclic loadings—and the effects of earthquakes and other natural forces on infrastructure. In 1990, he founded, and still directs, GW's Center for Infrastructure Safety and Reliability, where he and his associates and students explore dynamic and cyclic loadings on structures to predict how long a structural system will last if the foundation under it undergoes occasional violent erratic motion. Their research is supported by the National Science Foundation, the US Navy, the National Aeronautics and Space Administration, and the United States Agency for International Development.

Professor Sarkani joined the faculty of the School of Engineering and Applied Science of George Washington University in 1986, after earning his PhD from Rice University. He served as chair of the Civil, Mechanical, and Environmental Engineering Department from 1994 to 1997. From 1997 to 2001, he was SEAS Interim Associate Dean for Research and Development. Since 2001, he has served as Faculty Adviser for Off-Campus Programs in the Department of Engineering Management and Systems Engineering.

Thomas Mazzuchi – Thomas Mazzuchi is a professor of Operations Research and Engineering Management at the George Washington University. His current research interests include reliability and risk analysis, Bayesian inference, quality control, Stochastic models of operations research, and time series analysis.

Abstract

System complexity is only one aspect affecting US space acquisition today. There is a large body of literature that suggests US space acquisition is over budget, behind schedule, and delivering underperforming systems. The GAO seems to attribute a number of factors to contributing to this situation. However, three primary factors include an over-reliance on immature technology, managing requirements to build the "grand design" and the health of the space industrial base. Addressing these factors will be critical so that the US can maintain its technology superiority and leadership in space. This is especially critical as countries such as Russia and China continue to mount significant challenges to our dominance in space. A loss of US leadership in space could very well translate into a loss of prosperity and national security.

In this new century, those who effectively utilize space will enjoy added prosperity and security and will hold a substantial advantage over those who do not. In order to increase knowledge, discovery, economic prosperity, and to enhance the national security, the United States must have robust, effective, and efficient space capabilities. (Office of Science, 2006)

Introduction

Since the onset of the Cold War, the United States has led the development of space for exploration, commercial uses, and national interests. In that time, space has managed to permeate almost every aspect of our society and culture. In the span of forty some years, space has enabled global communications, broadcasted various forms of entertainment, assisted in geolocating new deposits of natural resources such as gas and oil, predicted the weather, provided information on our adversaries, and facilitated the conduct of successful military operations.

Despite our success, the national security of the United States faces an increasing risk of threat as a number of factors mount a significant challenge to our leadership in space. The Government Accountability Office (GAO) and others observe that a majority of these challenges may lie with our acquisition practices, procedures and policies. Their reviews suggest that many of our developmental national space systems are over budget, significantly behind schedule and woefully inadequate in terms of expected user performance. Lt. Gen. Michael Hamel, former commander of Air Force Space and Missile Systems Center, was pointed when he stated, “Nothing threatens US military superiority in space more than a loss of ability to develop, field and sustain our space systems” (Hamel, 2009).

Noting the challenges confronting the US space acquisition program, this paper seeks to accomplish three objectives. First, is to briefly explain the importance of US leadership in space by describing not only its historical development but also its contribution to the prosperity and national security of the United States. Second, it seeks to explain a small subset of the current acquisition challenges the US is facing, to include: dependence on immature technology, requirements, and the state of space industrial base. Finally, in conjunction with those challenges, this paper offers some modest recommendations that the acquisition community might employ to overcome these challenges and ensure US leadership in space.

The Space Development Imperative

Shortly after World War II, the US became engaged in the Cold War against its former ally, the Soviet Union. From a strategic perspective, the US recognized that, first, it needed a capable and credible nuclear deterrent against the Soviet Union and that, second, it needed to understand Soviet military developments and intentions. The development of intercontinental ballistic missiles (ICBMs) solved the US’s need to deliver nuclear warheads half way around the world. However, on the second issue, it still needed a means of obtaining information from denied areas. The shoot down of Gary Powers and his U-2 aircraft only accentuated the need for space systems capable of accessing denied areas. In other words, space development was the imperative.

Many organizations had aspirations for and were vying for control of space, and it wasn’t until the 1960s that the Air Force and the National Reconnaissance Office (NRO) would become the principal developers of military space power for the nation. During that time, there were rapid advances in communications, weather, navigation, missile warning, and intelligence surveillance (Hamel, 2009). These advances continued for the remainder of the Cold War. However, these space assets were typically only employed in a strategic and operational role. As the Cold War came to a close, and as Iraq flexed its military power in the Persian Gulf War, the perspective of using space systems as only strategic and operational assets quickly changed.

On August 2, 1990, Iraqi forces invaded the Kingdom of Kuwait, and the Iraqi government almost immediately annexed Kuwait as the nineteenth province of Iraq. From the early moments of the first Persian Gulf War, it became apparent that satellites were not only a force multiplier on the strategic and operation level but also on the tactical level. For the first time, satellites connected military forces, sensors, and decision-makers across the battlespace; collected data on operationally relevant conditions, reconnoiter, survey and target hostile forces; and enabled precision, synchronization and command and control of forces in the field (Hamel, 2009). As a result, Russia and China watched with disbelief as the American military easily dismembered and neutralized a Soviet-trained and -equipped military in a matter of days.

Since the close of the Persian Gulf War, the US military has increasingly relied on satellites to conduct and facilitate military operations. Additionally, the nature of warfare has evolved as adversaries recognize and attempt to negate the advantage that space systems provide for their American users. As a result, US military forces have asked for increasingly complex space systems in greater numbers and on faster timelines to answer the challenge posed by adversaries. This, in part, has contributed to the current state of US space acquisition.

The Acquisition Challenge

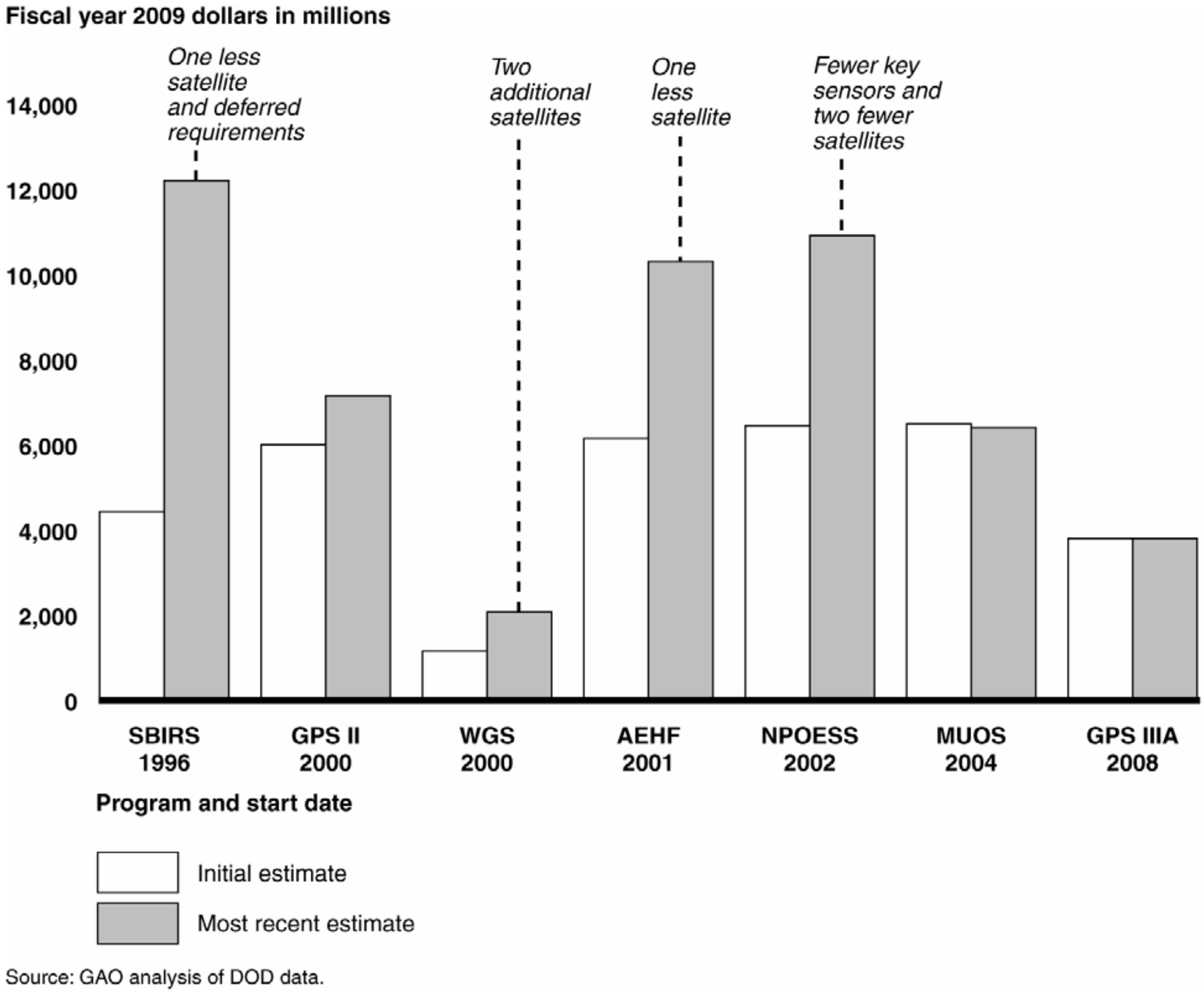
Without significant improvements in the leadership and management of national security space programs, U.S. space preeminence will erode 'to the extent that space ceases to provide a competitive national security advantage.' (Chaplain, 2009)

Recent studies conducted by the GAO suggest that major weapon system acquisition is a serious cause of concern for government leaders. For example, the GAO found that out of the DoD's portfolio of 96 programs, "42% are higher than originally estimated and the average delay in delivering initial capabilities has increased to 22 months" (Chaplain, 2009). Table 1 displays how costs have risen and schedules expanded for "big acquisition" from 2003 to 2008, using fiscal year 2009 dollars.

Table 1. Analysis of the DoD's Major Defense Acquisition Program Portfolios
(Francis, 2009)

Fiscal Year			
	2003	***2007***	***2008***
Portfolio size			
Number of Programs	77	95	96
Total Planned Commitments	$1.2 Trillion	$1.6 Trillion	$1.6 Trillion
Commitments Outstanding	$742.2 Billion	$875.2 Billion	$786.3 Billion
Portfolio Indicators			
Change to Total RDT&E costs from first estimate	37%	40%	42%
Change to Total acquisition cost from first estimate	19%	26%	25%
Total acquisition cost growth	$183 Billion	$301.3 Billion	$296.4 Billion
Share of programs with 25% increase in program acquisition unit cost growth	41%	44%	42%
Average schedule delay in delivering initial capabilities	18 Months	21 Months	22 Months

Unfortunately, the scenario does not fare much better for space acquisition either, as space systems cost estimates have risen dramatically. For example, the US Government is already expecting a $10.3 billion cost increase for the years 2009-2013 from original estimates (Chaplain, 2009). Obviously, these cost increases divert money away from new or existing space programs, making a cash-strapped environment for dollars even more competitive. Figure 1 displays the dramatic rise in cost and schedule delays for specific space acquisition programs.



Differences in Total Life-Cycle Program Costs from Program Start and Most Recent Estimates
(GAO, 2009)

The GAO has identified specific issues causing significant cost increases and schedule delays as well as presented several best practices they believe might alleviate them. First, the GAO found many acquisition programs begin with an over dependence on emerging technology. If an unexpected delay occurs in the development of the technology, it negatively impacts the program schedule (Chaplain, 2009). Second, many programs attempt to fulfill all requirements in a single step—that is to suggest that traditional acquisition approaches will not work given the current user demands and timelines coupled with complex capability. "Programs have historically attempted to satisfy all requirements in a single step, regardless of the design challenge or the maturity of the technologies necessary to achieve the full capability" (Chaplain, 2009). Finally, the state of the Space Industrial Base is questionable. First-tier contractors are showing only marginal profit revenues and can absorb loses as they are diversified across the acquisition market. However, a recent Air Force Research Laboratory (AFRL) survey suggests that second- and third-tier contractors are producing miniscule profits. Consequently, many of these contractors are disappearing or leaving the space industry for more lucrative markets.

Dependence on Emerging Technology

The GAO found that the DoD has a tendency to fund more programs then they can afford. As a result, many programs come into existence already underfunded. In fact, in a survey presented to space program managers asking what are the top obstacles to achieving success, over 36% stated unstable funding (Chaplain, 2006). Additionally, programs that are performing well often find funding transferred to an underperforming program. This creates a very competitive environment for both program managers and contractors. In an attempt to secure as much funding as possible, a program manager will often over promise on capability and focuses on “bleeding edge” technologies that seem to demonstrate “the most bang for the buck” to those in control of the purse strings.

Unfortunately, this reliance upon bleeding edge technology comes at a significant cost. The GAO has found that developing technology in conjunction with program development is often fraught with schedule delays and cost overruns because the relied-upon technology often doesn’t work out as intended. In the same survey that measured unstable funding as a major obstacle, 18% of space program managers interviewed admitted that they relied on immature and untested technology (Chaplain, 2006).

Specific examples of space programs relying upon immature technology include Space Based Infra-Red (SIBRs) satellite system, the Advanced Extremely High Frequency (AEHF) satellite system and the National Polar-orbiting Operational Environmental Satellite System (NPOESS). In some cases, the GAO noted that sensors had not been fully tested or even prototyped, or software needs in general were just greatly underestimated (Chaplain, 2006). This reliance upon immature technology can, in some part, account for the fact that these programs have experienced a cost increase of 40% or more since their original cost estimation (Chaplain, 2006). In the case of SBIRs, their costs have more than doubled (Chaplain, 2006).

The GAO has provided two primary recommendations to help alleviate the overdependence upon immature technology. First, based upon best industry practices, the GAO recommends separating technology development from acquisition development. Implied in this concept is that program managers will have to rely upon and select proven technology. This leads to their second recommendation, which is to apply the technology readiness level (TRL) scale that the DoD “borrowed” from NASA. This rating scale evaluates technologies against 9 different levels of developmental maturity. The first level represents the least mature technology, whereas the ninth level represents the highest level of technological maturity. In the case of space acquisition, the GAO is recommending that programs only select and use technology that has reached a technology level of seven. For this particular level, the technology should be tested at least once in an operational environment, which is defined as “an environment that addresses all of the operational requirements and specifications required of the final systems” (USD(AT&L), 2002). Not surprisingly, the DoD has pushed back on this recommendation and offers its own recommendation of selecting technology that has reached level six. This level demonstrates a prototype or model of a system or subsystem in a relevant end-to-end environment, which is described as a test environment that simulates the key aspects of the operational environment (USD(AT&L), 2002).

Requirements and the Grand Design

There are several areas of concern with regard to space acquisition and requirements. First, as was alluded to earlier, many programs attempt to satisfy all users requirements in a single, grand design. Second, users and stakeholders have demonstrated a tendency to frequently change or add new requirements as the program is developing. Not surprisingly, these factors undoubtedly impact cost and schedule. According to Dr. Rustan, Director of Mission Support Directorate, NRO,

> Our requirements-driven stakeholders often do not understand the cost implications of the various elements of their respective wish lists, and when we proceed to blindly integrate these capabilities, considerable problems develop. This problem is exacerbated when we are asked to hold fixed performance, cost and schedule at the beginning on any space acquisition, thereby inexorably increasing program risk. (Rustan, 2005)

Attempting to satisfy all stakeholders with a “grand design” is not only costly and has a long lead development time but also ineffective and perhaps impossible. Each stakeholder comes with their own needs and capabilities, which often come in conflict with other stakeholders requirements. For example, United States Southern Command (USSOUTHCOM) may come to the NRO and ask for an electrical optical satellite that can penetrate through dense jungle foliage. Whereas, United States Pacific Command (USPACOM) may ask for a satellite capable of performing broad area searches so they can identify ships in transit. Finally, US Central Command (USCENTCOM) may ask for satellite that can identify thermal signatures emanating from caves in an attempt to locate terrorist safe holds. Thus, designing this satellite becomes inherently complex because different technologies are required to achieve each of those capabilities. Not surprisingly, integrating these technologies so that they work together not only increases complexity but also increases risk to the budget and schedule.

Stakeholders also have a tendency to add or change requirements during the development of the system. According to Dr. Rustan, this may be attributed to new technology that has caught the user’s eye. Dr. Rustan also states that these stakeholders are often attempting to solve dynamic problems, problems that change and evolve rapidly over time (Rustan, 2005).

Spiral or Evolutionary development may well help alleviate some these problems. These acquisition strategies offer several advantages that seem to address the problems that are manifesting themselves in space systems development. More specifically, evolutionary acquisition acknowledges that not all requirements in a program are known up front. Therefore, evolutionary acquisition seeks to divide a program into more manageable increments or spirals in which the requirement can be more tightly defined. “Evolutionary acquisition’s primary goal is to reduce product cycle times by dividing and phasing requirements to produce initial capabilities sooner … EA addresses requirements and technology risks by allowing requirements to evolve over time” (Ford & Dillard, 2009). Thus, these strategies allow program managers to take a complex design and break it down into smaller, more manageable intervals. Additionally, they allow the program manager to provide an initial set of capabilities to the user sooner than traditional acquisition approaches. The ability to deliver capabilities may also help negate the effects of requirements creep as well.

However, there is new evidence suggesting that evolutionary development may actually be costlier and longer. More specifically, modeling and simulation performed by David Ford and John Dillard suggests that although spiral development may satisfy first phase requirements faster, it certainly is more expensive when compared to traditional acquisition approaches. Further, their modeling also suggests that it takes longer to satisfy all requirements when compared with traditional approaches (Ford & Dillard, 2009). See Table 2 for their results. Therefore, it would appear a comprehensive evaluation is needed to determine if the best practices recommended by the GAO will truly fix space acquisition.

Table 2. Performance Comparison of Three Simulated Acquisition Projects
(Ford & Dillard, 2009)

Performance Measure	**Units of Measure**	**Project Scenario**		
		Javelin	***Base Case Traditional***	***Base Case Spiral***
Duration to first requirement satisfied	Weeks	471	470	**397**
Duration to maximum requirements satisfied	Weeks	520	**518**	762
Total development cost	$1.0 Million	722	**719**	1,555
Requirements satisfied by deadline	Percent	**100**	91	18
Final requirements satisfied	Percent	**100**	91	91

State of Space Industrial Base

A robust science, technology, and industrial base is critical for US space capabilities … departments and agencies shall … encourage an innovative commercial space sector, including the use of prize competitions; and ensure the availability of space related industrial capabilities. (Office of Science, 2006)

When examining the health of the space industrial base there seems to be two primary issues. First, is the *International Traffic in Arms Regulation (ITAR)* export regulations controlled by the US State Department? Second, is their large dependence upon the US Government for business and revenue? Specifically, 60% to 65% of sales for the space industrial base were from the US Government between the years 2003 to 2006 (Chao, 2008). In either case, while the first-tier contractors (Northrop Grumman, Lockheed Martin and Boeing) are showing minimal profit margins, the second- and third-tier contractors are leaving the industry. They are either going out of business or don't feel there is enough of a business case to continue to engage in space acquisition.

ITAR is designed to prevent protected technology and munitions from transferring to other nations and to enable the US to maintain its technological superiority. It is administered by the US State Department and was brought about as a result of Chinese technological gains from their observation of US investigative techniques on the failed ASTAR II launch (DoD, 1998). Despite its good intentions, strong arguments are arising that it is failing to prevent space technology from developing in other nations and is hurting the US's technological superiority.

For example, many foreign competitors, such as Thales, are advertising their satellites as *ITAR* free. The benefit provided here is that foreign companies don't have to progress through a complex and confusing export license process to acquire similarly capable components. Additionally, many nations when issuing a request for proposal purposely restrict the response to their proposal to less than sixty days. This virtually eliminates US firms without having to worry about economic retaliation because US firms first have to apply for an export license under *ITAR* before they can compete. According to a recent survey conducted by AFRL, the average turn around time for a license approval was 106 days in 2006 (Chao, 2008). Thus, it would appear that *ITAR* is further encouraging US firms to remain dependent upon the government as it is increasingly difficult to enter and compete in international markets.

It would also seem that *ITAR* has encouraged foreign nations to develop their own space technology. For example, we are seeing greater cooperation among foreign competitors in space, particularly among the Europeans. Further, China is closing the space gap with the US. They have developed their own positional navigational system, conducted their first manned space flight, demonstrated a successful space walk and successfully tested anti-satellite weapons technology (Chao, 2008). This would suggest that *ITAR* is not achieving its objective of maintaining US technical superiority in space.

The Department of Defense (DoD) provided a report to the Congress in February 2006, stating that the aerospace and defense industry was outperforming companies listed on the S&P 500 (DeFrank, 2006). As a whole, the industry did seem to outperform the S&P 500. However, when looking specifically at the space industry, and especially the second- and third-tier suppliers, we see that these companies had significantly lower profit margins. A recent survey conducted by Air Force Research Laboratory shows that second- and third-tier suppliers were only bringing in profit margins of 4% to 6% (Chao, 2008). These low profit margins mean there is less revenue to invest in their personnel and in their research and development. Combined with pressures from prime contractors to provide the "best possible price," these companies become less competitive, and, thus, we see a "hollowing out [of] the supply chain" (Chao, 2006). Additionally, the Suppliers Excellence Alliance asserts that 50% of all second- and third-tier suppliers will cease to exist by 2011 (Chao, 2006). This represents a serious problem because the primary contractors subcontract out approximately 80% of their space acquisitions to these lower-tiered companies (Chao, 2008).

The Center for Strategic International Studies (CSIS) provides several recommendations that may help alleviate the current situation. First, the Department of State should conduct a technological review to determine which technologies are critical and which ones are not (Chao, 2008). However, simply labeling a satellite as a critical technology in its entirety seems counterproductive. Currently, the US is the only nation in the world that labels a satellite as a munition, whereas many European nations designate them as dual use technology. Second, provide authority to those entities involved in satellite exports to "review cases in a real time, case by case, specific time period" (Chao, 2008). Finally, those government entities involved in space acquisition should annually review the state of the space industrial base.

Summary

Although space acquisition originally provided the US with an advantage in the Cold War, it has also impacted nearly every aspect of our society. It plays a role in our banking and financial industries, provides entertainment, enables us to communicate half-way around the world, provides information on otherwise denied areas, and acts as a force multiplier in the conduct of military operations. The Persian Gulf War demonstrated the asymmetrical advantage that space systems provided for US forces. As a result, other nations made a series of steps and commitments to develop their own space assets. As the US became more reliant upon satellite technology, its users began expressing requirements for a greater number of systems with far greater capabilities.

System complexity is only one aspect affecting US space acquisition today. There is a large body of literature that suggests US space acquisition is over budget, behind schedule, and delivering underperforming systems. The GAO seems to attribute a number of factors to contributing to this situation. However, three primary factors include an over-reliance on immature technology, managing requirements to build the "grand design" and the health of the space industrial base.

Addressing these factors will be critical so that the US can maintain its technology superiority and leadership in space. This is especially critical as countries such as Russia and China continue to mount significant challenges to our dominance in space. A loss of US leadership in space could very well translate into a loss of prosperity and national security.

References

Azani, C., & Flowers, K. (2005, January-February). Integrating business and engineering strategy through modular open systems approach. *Defense AT&L*, 37-40.

Blakey, M.C. (2009, April 30). Testimony to Committee on House Armed Services Sub-committee on Strategic Forces, Space Systems Acquisition Statement.

Chao, P. (2008, February19). *Health of the US space industrial base and the impact of export controls*. Center for Strategic International Studies.

Diamond, J.M. (2001). Re-examining problems and prospects in US imagery intelligence. *International Journal of Intelligence and Counter-Intelligence*, *14*(1), 1-24.

Dillard, J.T. (2004, August-November). Toward centralized control of defense acquisition programs. *Defense Acquisition Review Journal*, 331-344.

Eiband, D. (2005, August-November). Innovative procurement strategies. *Defense Acquisition Review Journal*, 323-329.

Ford, D.N., & Dillard, J. (2009, July). Modeling the performance and risks of evolutionary acquisition. *Defense Acquisition Review Journal*, 143-158.

Fowler, D.N. (2001, Fall). Innovating the federal acquisition process through intelligent agents. *Acquisition Review Quarterly*, 151-166.

GAO. (2003, September). *Improvements needed in space systems acquisition management policy* (GAO-03-1073). Washington, DC: Author.

GAO. (2004, January 29). *Defense acquisitions risk posed by DOD's new space systems acquisition policy* (GAO-04-379R). Washington, DC: Author.

GAO. (2005, June 23). *Defense acquisition incentives and pressures that drive problems affecting satellite and related acquisitions* (GAO-05-570R). Washington, DC: Author.

GAO. (2005, July 12). *Space acquisitions: Stronger development practices and investment planning needed to address continuing problems* (GAO-05-891T). Washington, DC: Author.

GAO. (2006, April 6). *Space acquisitions: Improvements needed in space systems acquisitions and keys to achieving them* (GAO-06-626T). Washington, DC: Author.

GAO. (2006, June 1). *Defense acquisitions: Space system acquisition risks and keys to addressing them* (GAO-06-776R). Washington, DC: Author.

GAO. (2006, September). *Space acquisitions: DOD needs to take more action to address unrealistic initial cost estimates of space systems* (GAO-07-96). Washington, DC: Author.

GAO. (2009, April 30). *Defense acquisitions: Charting a course for lasting reform* (GAO-09-663T). Washington, DC: Author.

GAO. (2009, May 20). *Space acquisitions: DOD faces substantial challenges in developing new space systems* (GAO-09-705T). Washington, DC: Author.

GAO. (2009, May 30). *Space acquisitions: Government and industry partners face substantial challenges in developing new DOD space systems* (GAO-09-648T). Washington, DC: Author.

Gholz, E. (2007, February). A business model for defense acquisition under the modular open systems approach. *Defense Acquisition Review Journal*, 217-233.

Hamel, M.A. (2009, March 10). *America's leadership in space*. Memorandum for the President, Committee for US Space Leadership.

Hartman, J. (2009, April 30). Testimony to Committee on House Armed Services Sub-committee on Strategic Forces, Space Systems Acquisition Statement.

Jakovelijevic, M. (2006). Modular open system approach (MOSA) and TTP-based platforms for aerospace control systems. *IEEE*.

Kohler, R.J. (n.d.). *The decline of the National Reconnaissance Office*. Center for the Study of Intelligence. Retrieved June 3, 2008, from https://www.cia.gov/library/center-for-the-study-of-intelligence/kent-csi/docs/v46i02p.htm#author

Levin, C., & McCain, J. (2009, April). *Weapon system acquisition reform act 2009*. Washington, DC: US GPO.

Mazur, J., Jr. (2003, Winter). Acquisition secrets from the National Reconnaissance Office. *Air Force Journal of Logistics*, *27*(4), 4-13.

NRO Chief Operating Officer (COO). (2009, April 3). *Integration, verification and transition procedure* (CIVVTP).

Office of Science and Technology, Executive Office of the President. (2006, August 31). *US National Space Policy*.

Pagliano, G.J., & O'Rourke, R. (2004, April 8). *Evolutionary acquisition and spiral development in DOD programs: Policy issues for Congress*. CRS Report for Congress.

Program manager's guide: A modular open systems approach (MOSA) to acquisition. (2004, September). Open Systems Joint Task Force. Retrieved from http://www.acq.osd.mil.ostfj

Rendon, R.G. (2007). Using modular open systems approach in defense acquisitions: Implications for the contracting process. *IEEE*.

Richelson, J.T. (2002). Restructuring the NRO: From the Cold War's end to the 21st century. *International Journal of Intelligence and Counter-Intelligence*, *14*, 496-539.

Rustan, P.L. (2005, July 12). Testimony to the United States House of Representatives, House Armed Services Committee Hearing, Space Acquisition.

Shannon, M.J. (1994, June). The Clementine Satellite. *E&TR*, 1-11.

Spring, B. (2005, October 19). *Congressional restraint is key to successful defense acquisition reform* (No. 1885). The Heritage Foundation.

USD (AT&L). (2002, April). *Mandatory procedures for major defense acquisition programs (MDAPS) and major automated information system (MAIS) acquisition programs* (DoD 5000.2-R). Washington, DC: Author.

THIS PAGE INTENTIONALLY LEFT BLANK

2003 - 2010 Sponsored Research Topics

Acquisition Management

- Acquiring Combat Capability via Public-Private Partnerships (PPPs)
- BCA: Contractor vs. Organic Growth
- Defense Industry Consolidation
- EU-US Defense Industrial Relationships
- Knowledge Value Added (KVA) + Real Options (RO) Applied to Shipyard Planning Processes
- Managing the Services Supply Chain
- MOSA Contracting Implications
- Portfolio Optimization via KVA + RO
- Private Military Sector
- Software Requirements for OA
- Spiral Development
- Strategy for Defense Acquisition Research
- The Software, Hardware Asset Reuse Enterprise (SHARE) repository

Contract Management

- Commodity Sourcing Strategies
- Contracting Government Procurement Functions
- Contractors in 21st-century Combat Zone
- Joint Contingency Contracting
- Model for Optimizing Contingency Contracting, Planning and Execution
- Navy Contract Writing Guide
- Past Performance in Source Selection
- Strategic Contingency Contracting
- Transforming DoD Contract Closeout
- USAF Energy Savings Performance Contracts
- USAF IT Commodity Council
- USMC Contingency Contracting

Financial Management

- Acquisitions via Leasing: MPS case
- Budget Scoring
- Budgeting for Capabilities-based Planning

- Capital Budgeting for the DoD
- Energy Saving Contracts/DoD Mobile Assets
- Financing DoD Budget via PPPs
- Lessons from Private Sector Capital Budgeting for DoD Acquisition Budgeting Reform
- PPPs and Government Financing
- ROI of Information Warfare Systems
- Special Termination Liability in MDAPs
- Strategic Sourcing
- Transaction Cost Economics (TCE) to Improve Cost Estimates

Human Resources

- Indefinite Reenlistment
- Individual Augmentation
- Learning Management Systems
- Moral Conduct Waivers and First-tem Attrition
- Retention
- The Navy's Selective Reenlistment Bonus (SRB) Management System
- Tuition Assistance

Logistics Management

- Analysis of LAV Depot Maintenance
- Army LOG MOD
- ASDS Product Support Analysis
- Cold-chain Logistics
- Contractors Supporting Military Operations
- Diffusion/Variability on Vendor Performance Evaluation
- Evolutionary Acquisition
- Lean Six Sigma to Reduce Costs and Improve Readiness
- Naval Aviation Maintenance and Process Improvement (2)
- Optimizing CIWS Lifecycle Support (LCS)
- Outsourcing the Pearl Harbor MK-48 Intermediate Maintenance Activity
- Pallet Management System
- PBL (4)
- Privatization-NOSL/NAWCI
- RFID (6)

- Risk Analysis for Performance-based Logistics
- R-TOC AEGIS Microwave Power Tubes
- Sense-and-Respond Logistics Network
- Strategic Sourcing

Program Management

- Building Collaborative Capacity
- Business Process Reengineering (BPR) for LCS Mission Module Acquisition
- Collaborative IT Tools Leveraging Competence
- Contractor vs. Organic Support
- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to AEGIS and SSDS
- Managing the Service Supply Chain
- Measuring Uncertainty in Earned Value
- Organizational Modeling and Simulation
- Public-Private Partnership
- Terminating Your Own Program
- Utilizing Collaborative and Three-dimensional Imaging Technology

A complete listing and electronic copies of published research are available on our website: www.acquisitionresearch.org

THIS PAGE INTENTIONALLY LEFT BLANK

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL
555 DYER ROAD, INGERSOLL HALL
MONTEREY, CALIFORNIA 93943

www.acquisitionresearch.org