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THE ROLE OF LEAD SYSTEM INTEGRATOR

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by

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The Role of Lead System Integrator

Presenter: The Honorable Jacques S. Gansler, former Under Secretary of Defense for Acquisition, Technology, and Logistics, is a Professor and holds the Roger C. Lipitz Chair in Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. He is also the Director of both the Center for Public Policy and Private Enterprise and the Sloan Biotechnology Industry Center. As the third-ranking civilian at the Pentagon from 1997 to 2001, Gansler was responsible for all research and development, acquisition reform, logistics, advance technology, environmental security, defense industry, and numerous other security programs.

Before joining the Clinton Administration, Gansler held a variety of positions in government and the private sector, including Deputy Assistant Secretary of Defense (Material Acquisition), Assistant Director of Defense Research and Engineering (Electronics), Executive Vice President at TASC, Vice President of ITT, and engineering and management positions with Singer and Raytheon Corporations.

Throughout his career, Gansler has written, published, and taught on subjects related to his work. He recently served as the Chair of the Secretary of the Army's "Commission on Contracting and Program Management for Army Expeditionary Forces." He is also a member of the National Academy of Engineering and a Fellow of the National Academy of Public Administration. Additionally, he is the Glenn L. Martin Institute Fellow of Engineering at the A. James Clarke School of Engineering, an Affiliate Faculty member at the Robert H. Smith School of Business, and a Senior Fellow at the James MacGregor Burns Academy of Leadership (all at the University of Maryland). For 2003–2004, he served as Interim Dean of the School of Public Policy. For 2004–2006, Gansler served as the Vice President for Research at the University of Maryland.

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William Lucyshyn is the Director of Research and Senior Research Scholar at the Center for Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. In this position, he directs research on critical policy issues related to the increasingly complex problems associated with improving public sector management and operations, and how government works with private enterprise.

Current projects include modernizing government supply chain management, identifying government sourcing and acquisition best practices, and Department of Defense business modernization and transformation. Previously, Lucyshyn served as a program manager and the principal technical advisor to the Director of the Defense Advanced Research Projects Agency (DARPA) on the identification, selection, research, development, and prototype production of advanced technology projects.

Prior to joining DARPA, Mr. Lucyshyn completed a 25-year career in the US Air Force. Lucyshyn received his Bachelor Degree in Engineering Science from the City University of New York, and he earned his Master's Degree in Nuclear Engineering from the Air Force Institute of Technology. He has authored numerous reports, book chapters, and journal articles.

Adam Spiers is a Graduate Research Assistant at the Center for Public Policy and Private Enterprise in the School of Public Policy at the University of Maryland. In this position, he researches and writes draft versions of final reports on selected defense acquisition topics. He has coauthored "Using Spiral Development to Reduce Acquisition Cycle Times," published in September 2008 by the Naval Postgraduate School.

Spiers is currently pursuing a Master's in Public Policy, expected graduation May 2009. He graduated summa cum laude from the University of Maryland, College Park, with dual Bachelor of Arts degrees in Economics and History. Spiers currently plans to further his education by pursuing either a doctorate or a law degree.

Executive Summary[1]

The Department of Defense (DoD) (as well as other government agencies) has used a strategy of contracting with a Lead System Integrator (LSI) when pursuing large System-of-System (SoS) acquisition programs. A SoS acquisition program involves the purposeful integration of individual weapon systems, along with other task-oriented assets, yielding a sum greater than the constituent parts. A SoS acquisition program will typically integrate legacy systems with new weapons platforms; in some cases, however, a SoS program will completely design and integrate a new set of systems.

A SoS is most likely to attain its potential benefits if a sole entity is responsible for managing the process. In order to properly manage the risks of a SoS development, a responsible agent is needed to coordinate and manage the complex effort, provide commonality across multiple weapons platforms and ensure a common vision for the program. Responsibilities can include systems engineering, architecture development, cost estimating, element selection, and SoS validation. This function is known as SoS integration. Believing that it did not have the organic managerial capability to oversee such monumental development tasks, the government has employed private contractors, which have come to be known as Lead System Integrators (LSIs), to manage the development of selected SoS programs. Due to difficulties faced by the Coast Guard's Deepwater SoS development, Congress prohibited the awarding of new LSI contracts, effective October 1, 2010, to firms that supply systems hardware for the SoS or perform an inherently governmental function (Congress, 2008). Despite this prohibition, the SoS integration functions performed by LSIs remain critical if the government wishes to pursue SoS engineering programs.

The impetus for SoS development has two foundations. First, the military has adopted a new fighting doctrine known as Net-centric Warfare (NCW). NCW attempts to leverage the advantage of information integration by distributed "sensors and shooters" to fight more effectively. NCW is characterized by complete battlefield awareness, self-synchronization of forces, and the overwhelming and precise application of force. This doctrine potentially reduces individual weapon system requirements but raises new issues such as communication system vulnerabilities. Second, many military assets are approaching the end of their originally intended lifespan and require replacement. This situation is a result of a lack of military development during the 1990s, combined with the increase in military requirements since the terrorist attacks of 9/11/01.

System-of-systems acquisition provides the crosslink between the DoD's change of military doctrine and its need to modernize its current forces. A SoS development provides the DoD with the unique ability to simultaneously field the full range of capabilities that it seeks in its next generation of military units. The integrated nature of the SoS, centered around an extensive communications network, lays the groundwork for complete implementation of NCW.

System-of-Systems Engineering (SoSE) offers the military two significant potential benefits. First, SoSE enhances the value of the end product by purposely synthesizing the attributes of a group of units into something that is greater than the sum of the individual parts. Second, SoSE, by taking a holistic view of the project, has the potential to improve development

[1] Research conducted at the Center of Public Policy and Private Enterprise at the University of Maryland's School of Public Policy. Research partially sponsored by a grant from the Naval Postgraduate School. The full report is available at www.acquisitionresearch.net .

decision-making by better valuing overall development tradeoffs. In a SoS framework, the SoS development output is maximized, as opposed to individual assets. In order to achieve optimal SoS performance within affordability constraints, SoSE requires development tradeoffs among the assets that comprise a given SoS.

SoSE differs from traditional engineering in significant ways. Traditional engineering seeks to optimize the performance of a single system, given specific end-requirements. SoSE attempts to develop a certain overall mission capability. SoS has two unique challenges not faced by traditional engineering. First, a SoS has a theoretically infinite lifespan as elements come and go in the SoS as it evolves. As long as the mission capability is supported, the SoS changes to continue to fulfill its role, even as the elements that constitute the SoS can be continuously replaced. Second, a SoS has undefined requirements, within cost, schedule and technology constraints. Without a specified end-point that encapsulates firm performance requirements, engineers have difficulty making explicit tradeoffs in functionality. Traditional engineering practices are not adequate to develop a truly integrated SoS.

DoD faces many challenges that may undermine effective SoS development. DoD-wide challenges include greatly broadened military requirements in response to the terrorist attacks of 9/11; impending budget constraints, stemming from the need to increase federal mandatory spending programs as the baby boom enters retirement; the inadequate capability and capacity of the current acquisition workforce to undertake SoS development programs due, in part, to human resource management decisions since the end of the Cold War; and the consolidation of the defense industry, which has significantly reduced competition and eliminated many independent systems engineering firms (primarily through acquisitions by the weapon systems producers). SoS-specific challenges include: an inconsistent understanding of the term SoSE by the acquisition workforce (including the role of cost in systems engineering analyses); the lack of a codified approach to SoSE, a function of the newness of the process; the interconnected nature of SoS development—which, if not handled properly, could lead to systemic failure, as disaster in one portion can have deleterious ripple effects throughout the entire SoS; ensuring adequate adaptability, so the SoS is flexible enough to meet future needs but provides enough stability to be a base for future design; the scale of development that necessitates the simultaneous development of a large number of assets, each of which would have traditionally been viewed as a major acquisition program; and, finally, budget instability, which is a constant challenge to DoD programs but which SoS development is particularly susceptible to.

The LSI, like a traditional prime contractor, must oversee technological maturity and subsystem development, as well as make decisions regarding tradeoffs within the context of the entire program. LSIs, however, have been given broad, government-like authority to execute acquisition programs that includes development of individual system requirements, contracting for their development and procurement, and coordination of development schedules and efforts. The degree of authority and responsibility given to an LSI, however, depends upon the program in question. Regardless of the authority the government delegates to the LSI, the government is still responsible for the program and must oversee the actions of the LSI and retain final decision authority.

Although the government could potentially perform the SoS integration function, its acquisition workforce lacks the numbers of personnel with the required skills that this effort requires. Consequently, the government chose to employ LSIs for its two largest SoS programs: the Coast Guard's Deepwater and the Army's Future Combat Systems.

Congress has defined two types of LSI contracts. An LSI with SoS system responsibility is a prime contractor that is primarily responsible for developing or producing the SoS, but which will subcontract much of the actual work. In this case, the LSI is responsible for the delivery of the completed, integrated system to the government. An LSI without SoS system responsibility is a prime contractor that is delegated government-like authority to perform what are typically considered inherently governmental functions. Although Congress has defined LSI in only two ways, the relationship that exists between the government and its chosen LSI can vary considerably, depending on how the contract is structured.

A principal fear stemming from use of an LSI is that the entity infringes upon inherently governmental functions. Critics warn that by awarding LSI contracts, the government avoids its primary responsibility without being able to provide adequate oversight of the LSI. Ultimately, they argue, the LSI has a strong incentive to take actions beneficial to the firm at the expense of the government's interests—e.g., regarding make/buy decisions on elements of the system and shaping the architecture around the firm's products. Proponents of LSI believe the fears of critics are either unfounded or can be addressed by proper government oversight.

This report examines two case studies of LSIs, the Coast Guard's Integrated Deepwater System Project (Deepwater) and the Army's Future Combat Systems (FCS), to illustrate the challenges and benefits of using LSI by the federal government. Both programs have faced significant development challenges, especially in adapting to new requirements arising from post-9/11 legislation.

The Integrated Deepwater System Program is the Coast Guard's effort to completely modernize its entire service. The program has faced many challenges, including an increase in required capabilities, acceleration of the program, and a natural disaster. Deepwater has experienced significant cost increases and schedule slippages that have led to the cancellation of several components. Due to these problems, the Coast Guard has taken over the role of LSI, although the Coast Guard still relies upon the original LSI for support of their program management.

The Future Combat Systems, an Army brigade-modernization program, has also experienced cost growth and schedule problems. In this instance, initial development problems were compounded by an acceleration of the delivery schedule and the need to deliver incremental improvements to soldiers in the field that were not previously planned. Although the program has experienced some challenges, these are, in general, not attributable to the use of an LSI.

These case studies have produced three key "lessons learned." First, although SoS integration is widely acknowledged as necessary to pursue SoS development, the presence of an LSI is not a cure-all. The military, lawmakers and industry must limit development programs based upon immature technologies in order to avoid these development problems. Second, while the government retained final authority rule over all important decisions, the Coast Guard and Army have been criticized for not exercising effective oversight of the LSI. Third, as presented by the FCS case study, it is important for military and industry to establish key shared-interests early in the development process. The benefit of establishing key shared-interests should be built upon, however, consideration of resource constraints.

The authors of the report arrived at the following findings:

1. The military is committed to SoS development.

2. SoS engineering and integration is a complex undertaking.
3. SoS development and integration is still a maturing discipline.
4. Government does not currently have capability or capacity to perform SoSE.
5. LSI programs have experienced technical difficulty for a variety of reasons.
6. Despite retaining final decision authority, the government has not consistently provided effective oversight of private LSIs.
7. The greatest concern regarding the use of LSI is the government's delegation of "inherently governmental functions."
8. A potential conflict-of-interests exists for private LSIs.
9. Unified leadership of the SoS integration affords the best chance of successful completion.

The authors of this report arrived at several conclusions:

1. The government should continue development of SoS programs that, if developed correctly, offer the potential for better value—more capability at equal or lower cost—to the military, than do individual procurements.
2. The government must effectively partner with the private sector to adequately perform the LSI function. To perform its responsibilities adequately:
    a. The DoD must provide better oversight and write contracts that are better defined.
    b. The DoD should accelerate its efforts to recruit, hire, and retain the required human capital required for program oversight (and, when required, program management) for the challenging SoS acquisitions.
    c. The government should enforce hardware and software exclusion provisions for system-of-system integration contracts.
3. Congress should modify the prohibition on the use of LSIs to permit either: (1) small-scale limited programs for LSIs or (2) large-scale programs for LSIs that are willing to take hardware and software exclusions. These pilot programs will help the DoD examine and evaluate strategies to fully leverage private-sector capacity while ensuring adequate government oversight and avoiding conflict-of-interest concerns.

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Congress. (2008). *National Defense Authorization Act for Fiscal Year 2008* (H.R.1585 Sec. 802: Lead Systems Integrators). Retrieved from http://thomas.loc.gov/cgi-in/query/F?c110:7:./temp/~c110qDUaya:e661818

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- Strategic Sourcing

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- Collaborative IT Tools Leveraging Competence
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- Knowledge, Responsibilities and Decision Rights in MDAPs
- KVA Applied to Aegis and SSDS
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The Role of Lead System Integrator (LSI)

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NPS Acquisition Research Symposium
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Changes Driving Security Transformation

- **Holistic View of Security – World-wide terrorism; pandemics; weapons proliferation; rogue nuclear states; energy dependence; insurgencies; environment; mass migration; regional conflicts; transnational threats; resource access (i.e., water, critical materials)**
- **New Missions – Homeland defense; missile defense; counterinsurgency; stability and reconstruction; civilian cybersecurity; non-kinetic situational influence of operations**
- **Unpredictability – Requiring agility, rapid responsiveness, broad-based capability**
- **Defense Budget Changes – From Equipment to Personnel, O&M and Homeland Security; frequent changes cloud spending outlook and planning**
- **Technological Changes – Info. tech, biotech, nano-tech, robotics, high-energy lasers, etc. - and every warfighter and platform a "node" in a system-of-systems**
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- **Intelligence Changes – Integrated data; open-sources; Language and culture understanding; real-time intel flow between soldier/sensors and command structure**
- **Industrial Changes – Horizontal & vertical integration; commercial high-tech advances; open networked innovation; off-shore manufacturing**
- **Globalization – Technology and industry are globalized; geo-politics and scope of threats requires security coalitions; DoD no longer the leader in all military technologies; global financial markets enable borderless investing**
- **Isolationist/Protectionist Moves – "Buy-American"; Berry Amendment; ITAR, export controls; restrictions on foreign scholars, students, and S&T workers**
- **China – Future adversary, Economic Competitor, or Global "Partner"**
- **Domestic Economics – Health care; demographics; budget and trade deficit**
- **Government Workforce – Aging; wrong skill mix; rules vs. judgment; "managers" vs. "doers"; difficult to attract and retain top people**
- **Industry Workforce – Aging, eroded systems engineering skills; difficult to attract and retain top S&T people**
- **Congressional Reaction to "need to reform" – From personal abuses and poor performance all leading to risk averse behavior**

Move to System-of-Systems (SoS)

- The military has adopted a new fighting doctrine known as Net-Centric Warfare (NCW)—platforms are networked into a SoSs.
- System-of-Systems acquisition provides the crosslink between the DoD's change of military doctrine and its need to modernize its current forces.
- The integrated nature of the SoS, centered around an extensive communications network, lays the groundwork for complete implementation of NCW.

The DoD defines a SoS as "a set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities."

System-of-Systems (SoS)

A SoS is focused on a capability that is enduring, while mission and performance requirements change, the SoS will always require new systems to replace expiring assets. Generally a SoS will have the following features:

1. **Operational independence--**enables individual components to function autonomously, outside of the SoS, if necessary.
2. **Geographic distribution--**permits components to function in a coordinate manner even while geographically dispersed.
3. **Emergent behavior--**describes synergistic and new capabilities not inherent to the component systems individually, but that are attainable with their integration
4. **Evolutionary development--**acknowledges the potential growth in the capability of the SoS through modification of current components or the addition of new ones

With SoS development the DoD is able to optimize the capability of the SoS within cost constraints, rather than optimizing at weapon platforms—which could result in sub-optimization at the SoS level.

Traditional vs. SoS engineering

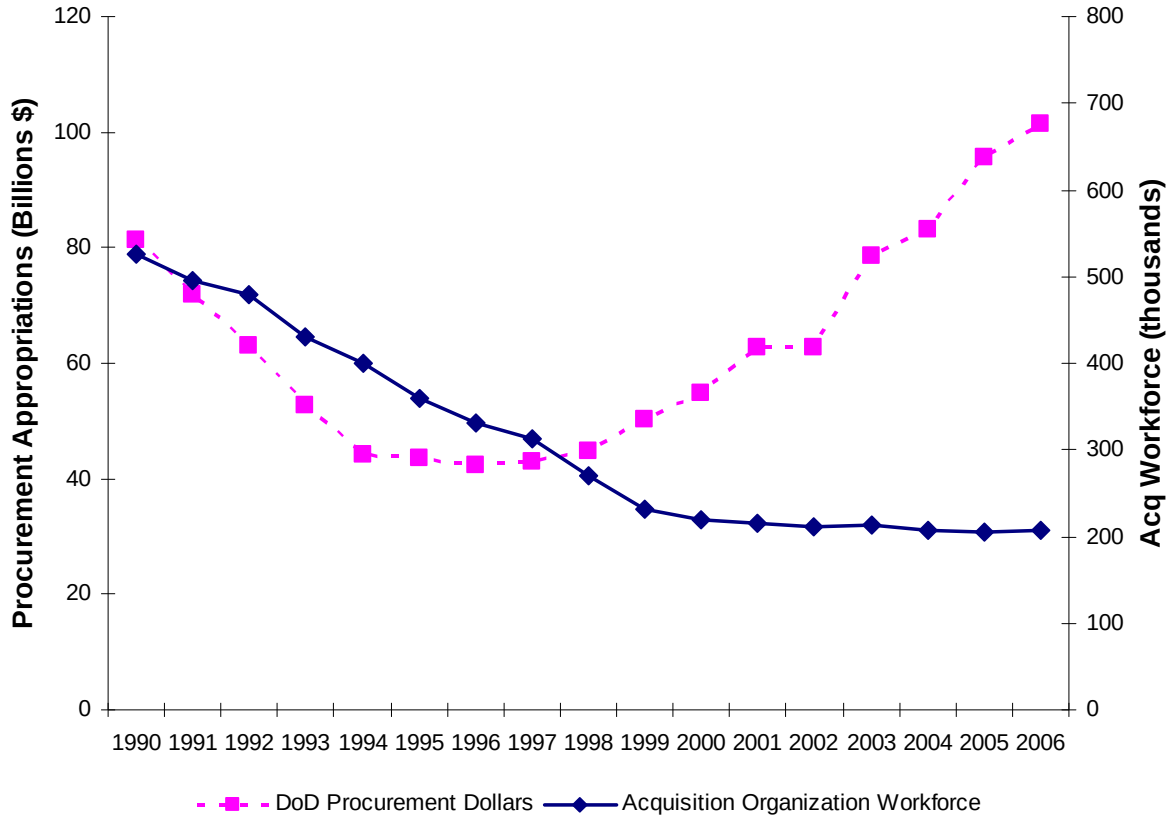
Significant differences exist between traditional and SoS engineering

	Traditional Engineering	SOS Engineering
Goal	Optimized system	Capability
Lifetime	Specific design lifetime	Indefinite lifetime
Design Requirements	Bounded	Unbounded
Size	Single system	Multiple systems
Governance	One dominant influence	Multiple, overlapping spheres of influence
Interdependent Development	Rare	Common

Challenges to SoS Acquisition

- The scale, complexity, and interconnected/interdependent nature of SoS
  - An inconsistent understanding of the term SoS and its implications
  - The lack of a standard approach to SoS engineering
  - Choosing or selecting interface standards
  - The requirement to ensure adequate adaptability
  - Testing at the SoS level
  - Information Assurance
- Extant budget and affordability processes for SoS (within DoD or Congress) still platform focused
  - Budget instability can also create significant program ripples
- The number and skill of system engineers, integrator, managers

Reduced Acquisition Workforce



Source of workforce data: DoD IG Report D-2000-088 Feb 29, 2000 & DoD IG Report D-2006-073 April 17, 2006

Source of budget data: Annual Defense Reports, available at http://www.dod.mil/execsec/adr_intro.html. Procurement supplementals for FY2005 and FY2006 not yet reflected in Annual Defense Reports were obtained from Congressional Research Service Reports. (Defense Science Board, 2008)

Lead System Integration (LSI)

- Complexity of SoS development requires a single entity to properly manage development, integration, and risks
- DoD employed private contractors as Lead System Integrators believing that it did not have the organic capability
- In some cases, contractor LSIs also have been given broad, government-like authority
  - development of individual system requirements,
  - contracting for their development and procurement
  - coordination of development schedules and efforts
- The degree of authority and responsibility given to an LSI, however, depends upon the program in question

Regardless of the authority the government delegates to the LSI, the government is still responsible for the program and must oversee the actions of the LSI and retain final decision authority

Private contractor as LSI

- In contrast to the government, private firms generally have
  - Ability to attract and retain the required technical expertise in much greater numbers than is the government, and as a result have greater capacity, capability, and flexibility
  - Competitive pressure, when contracts are properly structured
  - Access to more innovative technologies
  - Greater latitude when subcontracting due to greater budgetary flexibility
- As a result, a private LSI potentially provides the government with a flexible and an adaptable partner in SoS acquisition

Fears regarding use of a LSI

- Critics of LSI principally fear the entity infringes upon inherently governmental functions
  - **Loss of control--**government avoids its primary responsibility, without being able to provide adequate oversight of the LSI
  - **Conflict of Interest--**LSI has a strong incentive to take actions beneficial to the firm, at the expense of the government's interests
  - **Transparency--**Gov't may have insufficient visibility into program aspects such as program costs, optimization studies, source selections
  - **Competition--**May limit the option for future competition
- Proponents of LSI believe that the fears of critics are either unfounded or can be addressed by proper government oversight

Deepwater

- Objective: Replace the entire Coast Guard fleet with one modern SoS
- Original contract called for
  - Development of 15 major classes of ship and air vehicles
  - Delivery of over 450 new or modernized assets
  - Comprehensive C4ISR system

Deepwater Contract

- LSI chosen was Integrated Coast Guard Systems (a partnership between Lockheed Martin and Northrop Grumman)
- Contract worth up to $24 billion dollars over 30 years.
  - 5yr contract can be renewed up to five times with a maximum contract length of five years
- Deepwater contract had some unusual features:
  - Granted LSI great flexibility to determine program outcomes
  - Performance-based agreement that held the contractor accountable for its development decisions.
  - Complex structure, including numerous subcontracts types using different contract vehicles

Deepwater Development

- The program experienced many development problems, to include:
  - Conversion of legacy ships (from 110' to 123') cancelled, after two ships experienced hull buckling.
  - Due to this failure, the Coast Guard ordered the acceleration of the Fast Response Cutter (from a 2018 delivery date to 2007).
  - Significant cost overruns and schedule delays lead to the eventual termination of the ship.
- Due to criticism of Deepwater, the Coast Guard took over LSI responsibilities in April 2007, but retained the services of the Lockheed Martin-Northrop Grumman partnership.

Future Combat Systems

- The “Army’s first full-spectrum modernization in nearly 40 years” (US Army 2007)
  - Will eventually field 15 brigades
- The Army has dubbed this configuration “14+1+1”: fourteen weapons platforms, plus the advanced information network, plus the soldier

Non-Line-of-Sight Cannon

FCS Contract

- The LSI is Boeing, which has subcontracted management responsibilities with Science Applications International Corporation (SAIC)
- The Program Manager has make/buy oversight
- Originally an OTA contract with a high 10% fixed-fee, plus up to 5% in incentive awards of 15%
- Program came under congressional scrutiny for the high fixed fee, and potential conflict of interests
- Subsequently restructured to a CPFF and CPIF FAR-based contract with a fixed-fee of 3% and incentive award up to 12%

Future Combat Systems

The program has been restructured three times:

1. July 2004: Program restructured to meet new post-9/11 legislative requirements
   - Expanded mission portfolio
   - Rapid deployment through spiral development
2. Early 2007: Program restructured to maintain program costs within the new funding levels established in 2006.
   - Reduced the scope of FCS
   - Reduced number of assets to be purchased
   - Reduced the production rate for assets.
3. April 2009: Secretary Gates proposed budget for FY2010 cut heavy vehicles and refocused on other elements such as, ISR, Robots, C3, etc.

Congress Reacts

2008 Defense Authorization Bill (PL No: 110-181), Sec. 802. Lead Systems Integrators.

- Prohibits the Department of Defense from awarding new contracts for lead systems integrator functions beginning Oct. 1, 2010
- The bill also places an immediate ban on such arrangements for programs that are not yet in low-rate initial production

Findings

- DoD is committed to SoS development
- SoS engineering and integration is a complex undertaking
- SoS development is still a maturing discipline
- LSI programs have experienced technical difficulty for a variety of reasons to include:
  - Requirements growth in response to expanded mission profiles
  - Programs were accelerated—often based more on optimism than best engineering practices, resulting in development problems
  - Programs were started without a sufficient knowledge base—delay or failure of one platform has a negative ripple on the entire SoS

Preliminary Findings (cont)

- The government does not have the organic capability or capacity to perform the extensive systems engineering and integration tasks required by SoS
- The government needs objective/independent systems engineering and architecture advice from firms willing to take hardware/software exclusion contracts
- Despite retaining final decision authority, the government has not consistently provided effective oversight of private LSIs
- The greatest concern regarding the use of LSI is the government's delegation of "inherently governmental functions"
- A potential conflict of interests exists for private LSIs.
- Unified leadership of the system-of-system integration affords the best chance of successful completion

Recommendations

1. The government should continue development of SoS programs that offers significant benefits over individual acquisition projects
2. The government must assume the LSI responsibility
3. The government must effectively partner with the private sector to adequately perform the LSI function.
   - The DoD must provide better oversight and write contracts that are better defined.
   - The DoD should accelerate its efforts to recruit, hire, and retain the required systems engineering and program management human capital for program development and oversight
   - The government should plan to competitively award a “LSI support” contract to a firm capable of independent systems engineering, systems architecture, and systems costing
   - The government should enforce hardware and software exclusion provisions for the system-of-system integration contracts
   - Encourage the development of independent private sector systems engineering capability
4. Congress should modify the prohibition on the use of LSIs to permit LSI pilot programs to examine and evaluate strategies to fully leverage private sector capacity