U.S. GOVERNMENT ACCOUNTABILITY OFFICE
441 G St. N.W.
Washington, DC 20548

June 26, 2014

The Honorable Howard P. "Buck" McKeon
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

Defense Acquisitions: Review of Private Industry and Department of Defense Open Systems Experiences

This letter formally transmits the enclosed briefing that we presented to your staff on April 23, 2014. House Committee on Armed Services Report No. 113-102, which accompanied a House bill on the National Defense Authorization Act for Fiscal Year 2014, mandated GAO to provide a briefing on private industry best practices for implementing an open systems approach to product development (i.e., an approach that includes a modular design and standard interfaces).[1] This correspondence contains additional information not included in the briefing slides and addresses (1) industry practices and experiences for implementing an open systems approach during product development, (2) Department of Defense (DOD) initiatives and experiences for implementing an open systems approach on weapon acquisition programs, and (3) challenges DOD faces in implementing identified open systems practices on weapon system acquisition programs.

To conduct this work, we interviewed officials from four private companies (BP, Chevron, DreamHammer, and Iridium), standards organizations, and academia, and conducted literature reviews. The companies were selected based on their recent implementation of an open systems approach on a product. We reviewed relevant DOD policies, guidance, and handbooks, and interviewed officials from the Office of the Secretary of Defense and military services. We also discussed challenges selected private companies and some military programs had to overcome to implement an open systems approach with appropriate officials. Finally, we leveraged information from previous GAO reports where applicable.

We conducted this performance audit from February 2014 to June 2014, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

[1] H.R. 1960, 113th Cong. (1st Sess. 2013). A related bill, H.R. 3304, became the National Defense Authorization Act for Fiscal Year 2014, Pub. L. No. 113-66 (2013).

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Summary

GAO identified four private sector companies across various industries whose officials discussed examples of how they use an open systems approach to reduce product development time and life-cycle costs; increase competition and innovation; and enable interoperability between systems from different vendors, among other things. For example, major producers in the oil and gas industry use thousands of sensors on a typical oil drilling rig that are embedded in equipment managed by numerous service contractors. Because of this, they are using open standards to ensure that, regardless of who provides software for the disparate systems and sensors, they are interoperable because their data can be transferred in a common format and in near-real time for analysis at a central monitoring location. This open systems approach has helped oil companies avoid costly drilling mistakes that could cause drilling activities to shut down for a period of time and subsequent productivity losses. Another company that has benefited from using an open systems approach is Iridium, a satellite voice and data services provider, which expanded its customer base by transitioning from its initial proprietary service offering to one that allows partner companies to access Iridium's satellite communications network using commercially available modular components with open interfaces. This approach has increased innovation and opened competitive market opportunities through more than 300 partner companies, many of which have used these components to develop new tools such as tracking systems that function in remote areas worldwide. Further, it has also enabled Iridium to significantly increase its revenue from satellite communication services. Finally, DreamHammer reduced development costs and time by leveraging available software code for its unmanned vehicle control systems.

To achieve successes with open systems, officials we consulted—regardless of the industry sector they represent—highlighted a number of common enablers and practices. These include broad industry support and coordination with independent standards organizations; a long-term commitment to develop, implement, test, and refine standards; technical expertise to identify which components of a system should be designed to use open standards and interfaces; and knowledge sharing across all segments of an enterprise to build continuous support for open systems.

In recent years, DOD has emphasized the benefits of using an open systems approach in weapon acquisition programs, particularly through its 2010 and 2012 Better Buying Power Initiatives.[2] A 2013 Interim DOD Instruction 5000.02, "Operation of the Defense Acquisition System," provides that program managers are responsible for applying open systems approaches in product designs where feasible and cost-effective. Some of the tools indentified in the instruction were developed by an Open Systems Architecture Data Rights team co-chaired by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics and the Office of the Assistant Secretary of the Navy for Research, Development, Test and Evaluation. This team is a service-level organization that leverages prior open systems resources and current initiatives to develop contracting and other guidance for open system acquisitions.

While each of the military services has policies for incorporating open systems on their weapon acquisition programs, the Navy has made the greatest strides in institutionalizing open system

[2] Office of the Under Secretary of Defense, Acquisition, Technology and Logistics Memorandum: "Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending" (Sept. 14, 2010). Office of the Under Secretary of Defense, Acquisition, Technology and Logistics Memorandum: "Better Buying Power 2.0: Continuing the Pursuit for Greater Efficiency and Productivity in Defense Spending" (Nov. 13, 2012).

acquisitions, and a number of its programs have implemented such an approach from early development. Examples include three unmanned aircraft systems, the P-8 Poseidon maritime patrol aircraft, and the most recent effort to develop a replacement Presidential Helicopter. The Air Force and the Army are beginning to embrace open systems acquisitions as well, albeit in a more ad-hoc fashion, with some programs such as the Air Force's KC-46 Tanker showing promise for future life-cycle cost savings, according to program officials.

Despite the positive developments we identified in this review, as well as our July 2013 report, DOD continues to face a number of challenges to consistently applying practices for effectively implementing an open systems approach to weapon acquisition.[3] The most difficult challenge is overcoming a general cultural preference within the services for acquiring proprietary systems that puts life-cycle decisions in the hands of the contractors that developed and produced those systems. Those contractors, therefore, benefit from maintaining the status quo with respect to long-term weapon system sustainment. Although new open systems guidance, tools, and training are being developed, DOD is not tracking the extent to which programs are implementing this approach or if programs have the requisite expertise to implement the approach.

In our July 2013 report, we made four recommendations to improve DOD's implementation of an open systems approach for weapon acquisition programs, as well as its visibility of open systems implementation and program office expertise. We recommended that (1) the Air Force and Army implement their open systems policies, (2) DOD develop metrics to track open systems implementation, (3) the services report on these metrics, and (4) the services assess and address any gaps in expertise. DOD partially concurred with the recommendations, stating that existing policies and guidance are sufficient and any assessments to track and report on open system metrics should be made and reported on during existing reviews. DOD did not indicate how it would assess and address gaps in expertise.

DOD has not taken steps to implement our recommendations. Based upon additional information we obtained during this review, we continue to believe our recommendations are applicable.

Agency Comments

We requested comments from DOD, but none were provided.

We are sending copies of this report to the appropriate congressional committees. We are also sending copies to the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology and Logistics. This report will also be available at no charge on our website at http://www.gao.gov. Should you or your staff have questions concerning this report, please contact me at (202) 512-4841 or at sullivanm@gao.gov.

[3] In our July 2013 report we discussed both positive developments as well as challenges DOD faced in implementing an open systems approach to product development. See GAO, *Defense Acquisitions: DOD Efforts to Adopt Open Systems for Its Unmanned Aircraft Systems Have Progressed Slowly*, GAO-13-651 (Washington, D.C.: July 31, 2013).

Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Key contributors to this report were Cheryl Andrew, Assistant Director; Andrew H. Redd; Robert K. Miller; Katheryn Hubbell; Marie Ahearn; and Laura Greifner.

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Enclosure

GAO

Review of Private Industry and Department of Defense Open Systems Experiences

Briefing to Staff
House of Representatives
Committee on Armed Services
April 23, 2014

For more information, contact Michael J. Sullivan, (202) 512-4841, sullivanm@gao.gov Page 1

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Engagement Objectives

House Committee on Armed Services Report No. 113-102, which accompanied House Bill H.R. 1960 on the National Defense Authorization Act for Fiscal Year (FY) 2014 mandated GAO to provide a briefing on private industry best practices for implementing open systems—products that rely on standards-based, modular architectures or designs. This briefing addresses:

1. What are industry practices and experiences for implementing an open systems approach during product development?
2. What are Department of Defense (DOD) initiatives and experiences for implementing an open systems approach on weapon acquisition programs?
3. What challenges, if any, does DOD face in implementing identified open systems practices on weapon system acquisition programs?

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Scope and Methodology

To identify the industry practices and experiences for implementing an open systems approach during product development, we

- interviewed officials from selected private companies (BP, Chevron, Iridium, DreamHammer), standards organizations, and academia.

To identify DOD initiatives and experiences for implementing an open systems approach on weapon acquisition programs, we

- reviewed relevant DOD policies, guidance, and handbooks,
- interviewed officials from the Office of the Secretary of Defense and military services, and
- leveraged information from previous GAO reports.

To determine challenges, if any, DOD faces in implementing identified open systems practices on weapon system acquisition programs, we

- discussed challenges selected private companies and some military programs had to overcome to implement an open systems approach with appropriate officials, and
- leveraged information from previous GAO reports.

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Background

Traditionally, DOD has acquired proprietary systems that limit opportunities for competition and cannot readily be upgraded. For example,

- The Air Force is spending over $2 billion to upgrade the B-2 bomber's communications, networking, and defensive management capabilities. Because the B-2 program's prime contractor is the sole system integrator in possession of proprietary technical data and software, there is no opportunity for competition (a critical tool for driving down costs).
- The Air Force planned to replace the aging avionics systems on its C-130 aircraft with open architecture avionics systems. However, because of the various configurations, the upgrades required custom-built hardware and software; less expensive commercial off-the-shelf technology could not be used. As a result, C-130 modernization cost estimates increased from $4 billion to over $6 billion and the number of planes to be modernized decreased from 519 to 221. The Air Force is now proposing a scaled-down, cheaper upgrade effort in its fiscal year 2015 budget.

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Background

One way for DOD to minimize the cost and time needed to modify or upgrade weapon systems is by using an open systems approach for system design and development.

Table 1: Fundamental Elements of an Open Systems Approach

Characteristics	Description
1. Modular components	Modular components that isolate system functions make the overall system easier to develop, maintain, and modify because components can be added, removed, modified, or replaced by consumers without majorly impacting the remainder of the system.
2. Open, publicly available standards for key interfaces	Interface standards specify the physical, power, data and/or other specifications for connections between components. Open, publicly available standards should be identified for key interfaces, which are those between the modules that are likely to change, may frequently fail or need to be replaced, or are needed for interoperability.
3. Acquirable data rights	When open standards are not available, data rights for key interfaces should be obtained. The acquisition of technical data, such as design drawings or specifications, is critical to enabling DOD opportunities for modification and sustainment of weapon systems throughout their life cycles.

Source: GAO.

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Background

Manufacturers and customers can achieve several benefits through the use of open systems:

- *Increased competition*: open standards allow many suppliers to compete in the marketplace, reducing dependency on any single supplier for parts or upgrades.
- *Reduced life-cycle cost*: open designs can result in lower development, procurement, and sustainment costs over time.
- *Increased innovation*: new, technologically advanced products can be driven by competition.
- *Increased ability to pursue an incremental approach*: allows manufacturers to develop more capable products over time.
- *Reduced schedule*: development time for manufacturers is reduced because parts are easier to integrate
- *Faster and less costly repairs/upgrades*: upgrades and repairs take less time and are less costly for consumers.
- *Enhanced interoperability*: interoperability among products is enhanced when different products adhere to the same standards.

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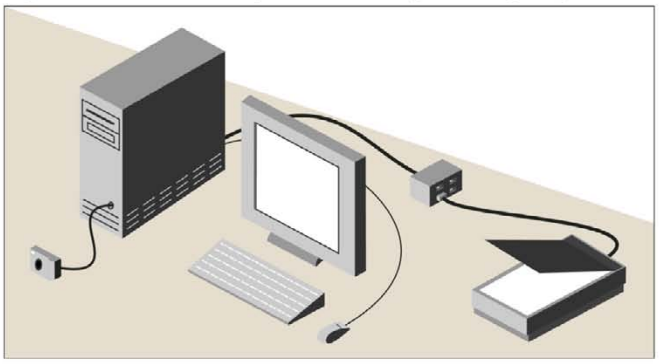
Objective 1:
Private Industry Experiences with Open Systems

IBM helped revolutionize the personal computer industry by openly publishing its hardware and software specifications. As a result:

- The number of manufacturers developing computers and related devices such as printers and scanners has increased substantially
- Third-party suppliers are developing software applications that can be used on computers
- The price of personal computers has dropped dramatically from $1,565 (the first IBM personal computer) to as little as $400.
- Computers have 500 times the processing power of IBM's early personal computer.

Figure 1: The Personal Computer as an Example of an Open System



Source: GAO analysis of DOD and industry data. | GAO-14-617R

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Private Industry Experiences with Open Systems

According to company officials we spoke with, the oil and gas industry has been actively driving the use of standards for more than 10 years. Specifically, oil and gas companies are beginning to take advantage of opportunities to use standards-based open systems in drilling and production monitoring, which is expected to enhance safety and productivity and result in faster and less costly repairs.

- Oil and gas companies are cooperating to develop and adopt standards for collecting and transmitting asset performance, failure, and maintenance data in standard formats.
- One major oil and gas company employs a software solution based on industry-developed standards to transfer data from thousands of sensors, such as those that monitor drill speed and friction, to help personnel know when to slow down the drill in a section where it is likely to get stuck. A company official noted that for a relatively small expenditure, standardized data transfer tools have helped the company avoid significant productivity losses that would normally arise when a contractor has to stop operations.
- Through specific contract mechanisms, another major oil and gas company has begun to require compliance with standards-based interfaces for computerized maintenance monitoring systems. This enables more targeted and timely repair of equipment. The company also expects to reduce software licensing costs by reducing reliance on individual vendor software packages.

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Private Industry Experiences with Open Systems

Iridium officials told us that, after limited business success with its initial proprietary satellite phone and voice service offering, Iridium developed user equipment kits with modular, open interfaces that accelerated applications for new markets.

- More than 300 partners have used Iridium's modular components to develop new products that use Iridium's communications network (e.g., to transmit/receive data from remote pipeline gauges and for maritime package tracking).
- Total service revenue grew 42 percent during the last 3 years through products newly connected to the communications network

Currently, Iridium is planning an additional satellite network, linked to the primary network, that will allow customers to host payloads—devices needed for the satellite to carry out its mission—on board Iridium satellites

- The hosted payloads tailored for the customer's own applications will communicate through the Iridium network using open interface standards.

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Private Industry Experiences with Open Systems

DreamHammer officials affirmed their support for standards-based open source architectures for unmanned systems. Specifically, they noted:

- DreamHammer combined the flexibility of open source software and standard interfaces to create a more cost effective and highly adaptable user interface for its customers. Their use of an open systems approach allowed them to
  - focus on solutions that make their software easy to integrate,
  - create innovative technology that allows for increased interoperability of multiple unmanned aircraft systems platforms with a single interface, and
  - incorporate encrypted radio link solutions for security
- DreamHammer's product is made up of approximately 2 million lines of code, only 200,000—or 10 percent—was written by DreamHammer itself, resulting in a reduction in development costs and time to the company.

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Private Industry Experiences with Open Systems

Auto Industry Example

- Various auto manufacturers and technology companies are cooperating through the Open Automotive Alliance to use the Android platform and open development model to more seamlessly integrate familiar mobile technology into cars. This is expected to improve safety by enabling drivers to more easily focus on the road, while allowing application developers new avenues of innovation.

Mobile Phone Industry Example

- Leading tech firms are collaborating on the development of the first modular smart phone that uses a common hardware interface to allow for third-party creation of interchangeable components (e.g., screens, batteries, memory, cameras, and those not yet invented). This will allow consumers to tailor phone capabilities to their own needs, and is also expected to decrease ownership costs by facilitating competition at the module level and increasing overall phone longevity by enabling consumer-level upgrades and repairs.

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Private Industry Experiences with Open Systems

To achieve successes with open systems, companies we consulted highlighted the following common implementation enablers and practices:

- Broad industry participation and support in developing and adopting standards. This creates demand for open systems and drives software and hardware suppliers to develop compliant, open products as they strive to remain competitive across the industry.
- A long-term commitment by the company to participate in the development, testing, and refinement of standards; and strategic integration to maximize savings (e.g., pilot programs).
- Technical expertise to identify component interfaces that should be open and which standards to employ or develop.
- Knowledge sharing across all departments to promote benefits, achieve leadership support, secure necessary investments, and minimize duplication of effort and development cycle times.

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Objective 2:
DOD Open Systems Initiatives and Experiences

DOD's Better Buying Power initiative put emphasis on open systems for DOD acquisition programs.[1] As part of its efforts, DOD:

- Formed an Open Systems Architecture Data Rights Team co-led by the Office of the Deputy Assistant Secretary of Defense for Systems Engineering and the Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation.
- Issued a contract guidebook in 2013 intended to assist program managers in incorporating open systems principles into their acquisition programs.
- Updated systems engineering guidance in the Defense Acquisition Guidebook, which now recommends that program managers update key documents to reflect open systems strategies.
- Leveraged existing resources including an analytical tool for programs to monitor and evaluate their open systems implementation.

[1] Office of the Under Secretary of Defense, Acquisition, Technology and Logistics Memorandum: "Better Buying Power: Guidance for Obtaining Greater Efficiency and Productivity in Defense Spending" (Sept. 14, 2010). Office of the Under Secretary of Defense, Acquisition, Technology and Logistics Memorandum: "Better Buying Power 2.0: Continuing the Pursuit for Greater Efficiency and Productivity in Defense Spending" (Nov. 13, 2012).

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DOD Open Systems Initiatives and Experiences

We recently found that the services vary in the extent to which they have adopted open systems for DOD's 10 largest UAS.[2]

- Three of the Navy's four current and planned UAS programs incorporated, or are planning to incorporate, an open systems approach. Expected benefits include:
  - Small Tactical Unmanned Aircraft System program officials anticipate that they will be able to independently integrate at least 32 different payloads developed by 24 different manufacturers.
  - Triton program officials estimated that software testing could be reduced by as much as 66 percent compared to systems that do not have an open system design, because only the new functionality needs to be tested, not the entire system.
- The Army did not initially include an open systems approach for its three UAS programs, but has since begun upgrading to a universal ground control station that incorporates an open architecture.
- None of the Air Force's three UAS programs were initially developed as an open system, and only one is being upgraded to include an open systems approach.

Figure 2: Adoption of an Open Systems Approach on Unmanned Aircraft Systems

Service	Unmanned aircraft system program	Adopted approach at the start of development
Navy	Small Tactical Unmanned Aircraft System	✓
	Triton	✓
	Unmanned Carrier-Launched Airborne Surveillance and Strike	✓[a]
	Fire Scout	---
Army	Gray Eagle	---
	Hunter	---
	Shadow	---
Air Force	Reaper	---
	Global Hawk	---
	Predator	---

✓ Open systems approach adopted at the start of development for the air vehicle, ground control station, and payloads, such as cameras and radar sensors

--- Open systems approach not adopted at the start of development for the air vehicle, ground control station, and payloads

Source: GAO analysis of DOD data. | GAO-14-617R

[a]The Unmanned Carrier-Launched Airborne Surveillance and Strike program is a planned acquisition program that has not yet started development.

[3] GAO, *Defense Acquisitions: DOD Efforts to Adopt Open Systems for Its Unmanned Aircraft Systems Have Progressed Slowly*, GAO-13-651 (Washington, D.C.: July 31, 2013).

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DOD Open Systems Initiatives and Experiences

Other DOD programs are starting to implement an open systems approach at the start of development, and DOD estimates that these programs will avoid considerable repair and upgrade costs as a result.

Table 2: Examples of DOD Programs Implementing an Open Systems Approach and Their Expected Benefits

DOD Program	Expected Benefits
Navy P-8 Poseidon	The program combines the use of a commercially available airframe with a number of open key interfaces and use of mainstream computing products to enable more affordable and timely future upgrades. Ten percent of the Engineering and Manufacturing Development contract is contingent upon compliance with open architecture specifications.
Navy VXX Presidential Helicopter	The program combines the use of a commercially available airframe with a government furnished and controlled mission critical communications system. Program officials estimate cost savings of approximately $570 million over the life of the platform as a result of not having to pay for proprietary upgrades over time.
Air Force KC-46 Tanker	The program plans to use a commercially available airframe and a number of modular open systems which will allow the Air Force to use an open approach for new or modified systems, as well as lead the maintenance of the aircraft. Officials expect these practices to lead to an overall decrease in the cost to maintain, repair, and upgrade the subsystems over the life of the program.
Air Force Space Fence	The program has planned for a modular open systems approach, which includes open, service oriented, flexible, expandable/scalable, and loosely coupled architecture. In addition, the program plans to maximize the use of open (industry established) external and internal interface standards.

Source: GAO analysis of DOD data.

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Objective 3:

Challenges DOD Faces in Implementing Open Systems

We have previously found that DOD faces a number of challenges to successfully change its approach from one that procures proprietary systems to one that procures open systems.[3] For example:

- Strong leadership is needed to overcome military service preferences (culture) for acquiring proprietary systems. Various independent standards experts, DOD contractors, and DOD systems engineering officials identified DOD leadership as key to effective adoption of an open systems approach.
- Prime contractors are content not to provide open systems because they are able to achieve greater financial benefits by selling DOD proprietary products, which they alone can integrate, maintain, and upgrade over the life of the program.
- The Office of the Secretary of Defense (OSD) does not have adequate insight of the extent to which an open systems approach is being used by individual weapon acquisition programs.
- OSD does not know if program offices have the systems engineering expertise required for effective implementation of an open systems approach or if additional expertise is needed.

[3] GAO-13-651.

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Challenges DOD Faces in Implementing Open Systems

Last year, we made four recommendations to improve the DOD's implementation of an open systems approach for weapon acquisition programs, as well as its visibility of open systems implementation and program office expertise.[4]

1. The Air Force and Army should implement their open systems policies.
2. DOD should develop metrics to track open systems implementation.
3. The services should report on these metrics.
4. The services should assess and address any gaps in expertise.

DOD partially concurred with the recommendations, stating that existing policies and guidance are sufficient and any assessments to track and report on open system metrics should be made and reported on during existing reviews. DOD did not indicate how it would assess and address gaps in expertise.

While we agreed that the guidance is sufficient, we found that the Air Force and Army are not implementing the policies consistently. We also agreed that the milestone decision process is an appropriate venue to review programs' open systems strategies, but that OSD does not have adequate insight of the extent to which an open systems approach is being used by programs and thus cannot have reasonable assurance of the widespread use of an open systems approach across the department.

DOD has not taken any steps to implement the recommendations.

[4] GAO-13-651.

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Conclusions

- According to industry officials we spoke with, adopting an open systems approach has helped commercial companies in our review achieve significant benefits, such as:
  - Lowering total ownership and operating costs,
  - Generating efficiencies for product manufacturers, and
  - Increasing competition, resulting in industry growth and entrepreneurial creativity.
- We identified several DOD weapon acquisition programs that have or plan to adopt open systems and also expect to achieve significant benefits.
- DOD faces a number of challenges to implementing open systems on its weapon acquisition programs, of which culture appears to be the most difficult to overcome.

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