

**GAO**

Report to the Chairman, Subcommittee  
on Air and Land Forces, Committee on  
Armed Services, House of  
Representatives

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June 2007

# DEFENSE ACQUISITIONS

## Analysis of Processes Used to Evaluate Active Protection Systems





Highlights of [GAO-07-759](#), a report to Subcommittee on Air and Land Forces, Committee on Armed Services, House of Representatives

## Why GAO Did This Study

Active Protection Systems (APS) protect vehicles from attack by detecting and intercepting missiles or munitions. In 2005, the lead systems integrator for the Army's Future Combat Systems (FCS) program sought proposals for an APS developer and design and to deliver APS prototypes on vehicles by fiscal year 2009. Raytheon was chosen the APS developer. At the same time, the Department of Defense's Office of Force Transformation (OFT) evaluated near-term APS for potential use in Iraq.

GAO was asked to review the Army's actions on APS/FCS: (1) the process for selecting the subcontractor to develop an APS for FCS and if potential conflicts of interest were avoided; (2) the timing of the trade study and if it followed a consistent methodology to evaluate alternatives, and the results; (3) the role the Army and Boeing played in selecting the developer; and (4) the process followed to provide a near-term APS solution for current forces.

## What GAO Recommends

GAO recommends that the Secretary of Defense support additional testing and demonstration of APS systems to help develop tactics, techniques, procedures, and concepts of operations for active protection systems and provide useful data on the use of APS. DOD did not agree to support such testing.

[www.gao.gov/cgi-bin/getrpt?GAO-07-759](http://www.gao.gov/cgi-bin/getrpt?GAO-07-759).

To view the full product, including the scope and methodology, click on the link above. For more information, contact Paul Francis at (202) 512-4841 or [francispg@gao.gov](mailto:francispg@gao.gov).

## DEFENSE ACQUISITIONS

# Analysis of Processes Used to Evaluate Active Protection Systems

## What GAO Found

In selecting the APS developer, the Army and Boeing—the FCS lead systems integrator—followed the provisions of the FCS lead systems integrator contract, as well as the Federal Acquisition Regulation, in addressing organizational conflicts of interest. No officials from the offering companies participated in the evaluation and all offerors were evaluated based on the same criteria. Four proposals were evaluated and three were determined to be comparable in terms of cost and schedule. The winner—Raytheon—was chosen on technical merit, as being more likely to meet APS requirements although its design had less mature technology.

The APS development contract required the source selection winner to perform a trade study to assess alternatives and select the best design for development, and the Raytheon design was chosen. The trade study applied a consistent methodology to all alternatives before selecting Raytheon's vertical launch design. While the role played by Raytheon in the trade study was in accordance with its contract, the rationale for having the trade study follow the source selection is not entirely clear. The purpose of the trade study was to select the best concept; yet the source selection process that preceded it had, in fact, chosen Raytheon primarily on the technical merits of its vertical launch design concept. Although the vertical launch technology is not mature, the Army estimated that it could be available for prototype delivery to current force vehicles in fiscal year 2009 and tested on a FCS vehicle in 2011. This may be an optimistic estimate, as the FCS vehicle is yet to be fully developed.

The Army and Boeing were extensively involved in APS source selection and the trade study. FCS officials actively participated and concurred in the final selection of the APS developer. FCS officials and technical experts from Army research centers took part in the trade study and helped choose the vertical launch design. Boeing officials took part in various ways and, with the Army's concurrence, selected Raytheon as the APS developer, participated in the trade study, and recommended the vertical launch approach.

In its pursuit of a different APS concept, OFT was responding to an urgent need statement issued by the Central Command with potential for near-term fielding. This evaluation centered on the results of physical testing of the most technically mature candidate system, the Trophy. Decisions on how to proceed with Trophy involved disagreement between OFT and the Army. While the Trophy tests were successful, the Joint Rapid Acquisition Cell decided to defer fielding the APS system, based in part on the recommendation of Army officials, who believed that testing had not been realistic and integrating it on the platform would delay fielding other useful capabilities. OFT officials proposed additional testing of Trophy to answer these questions, but funding for further OFT testing of this system was discontinued after the Joint Rapid Acquisition Cell's decision.

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## Abbreviations

APS	Active Protection System
DOD	Department of Defense
FAR	Federal Acquisition Regulation
FCS	Future Combat System
JUON	Joint Urgent Operational Need
RFP	Request for Proposal
OFT	Office of Force Transformation
OSD	Office of the Secretary of Defense
SAIC	Science Applications International Corporation
TRL	Technology Readiness Level

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United States Government Accountability Office  
Washington, DC 20548

June 8, 2007

The Honorable Neil Abercrombie  
Chairman  
The Honorable Jim Saxton  
Ranking Member  
Subcommittee on Air and Land Forces  
Committee on Armed Services  
House of Representatives

An Active Protection System (APS) is intended to protect a vehicle from attack by detecting and intercepting missiles or munitions before they hit the vehicle. It has significant possibilities for offering light vehicles some of the protection that armor gives, without the extra weight. In April 2005, BAE, a subcontractor for the Army's Future Combat System (FCS) program, issued a draft request for proposals to choose the developer for an APS for FCS and current force manned ground vehicles. To avoid an organizational conflict of interest, the lead systems integrator, the Boeing Company, ultimately reissued the draft request for proposals, after BAE decided to submit its own bid on this contract. Raytheon was eventually chosen as the APS developer and a subsequent trade study reached the conclusion that Raytheon's vertical launch concept was the optimal solution to meet the APS requirements. Also, in April 2005, the U.S. Central Command issued an urgent operational need statement to field a combination of near-term technologies, including a different APS, on a modified Stryker vehicle, the Full-Spectrum Effects Platform, for demonstration and potential use in Iraq. The effort made in response to this need was managed by the Office of Force Transformation (OFT), which reported to the Secretary of Defense. After evaluating six candidate APS, the OFT chose to test the Trophy APS because they considered it to be the most technically mature. In June 2006, the Joint Rapid Acquisition Cell decided to defer fielding the APS system.

Both the Army's FCS program and the OFT effort were looking for APS applications for current Army forces, but with somewhat different objectives in mind. Although the primary focus of the APS subcontractor selection and trade study was to pick a developer and a design for the FCS APS, another objective was to field an APS on current force combat

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vehicle platforms in the 2009 time period.<sup>1</sup> On the other hand, the OFT worked on a separate objective aimed at providing these capabilities sooner to forces currently in theater, to provide a nearer-term demonstration of APS.

This letter is to respond to your request for a review of the process that led to the Army's decision to pursue a new APS system under the FCS program. You asked us to review this process because of uncertainty surrounding the facts that led to the Army's decision to pursue a vertical launch APS concept. Specifically, this report addresses:

1. The process for selecting the subcontractor to develop an APS for FCS and whether potential conflicts of interest were avoided.
2. The timing of the trade study, whether it followed a consistent methodology to evaluate all the alternatives, and the results.
3. The role the Army and the lead systems integrator played in selecting the APS developer.
4. The process followed for evaluating a near-term APS solution for current forces.

In conducting our work, we held discussions with FCS, Army, and other DOD officials. We reviewed documents relevant to the decision the Army made about which APS system to pursue and held discussions with key officials about various decisions that have been made in pursuing this technology. We conducted our work between October 2006 and June 2007 in accordance with generally accepted government auditing standards. Appendix I further discusses our scope and methodology.

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## Results in Brief

In choosing the developer for the APS system, the FCS lead systems integrator ran a competition, with Army participation in the process and concurrence in the selection. The contractor followed the organizational conflict of interest clause developed in accordance with the FCS contract and applicable to all subcontract tiers under the FCS contract, as well as

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<sup>1</sup>The Army defines its "Current Force" as including the Stryker, Bradley, and Abrams combat vehicles. Of the three, the Stryker is the only system for which the Army has definite plans to incorporate an APS.

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the applicable Federal Acquisition Regulation (FAR) provisions. According to these terms, subcontractors cannot conduct or participate in a subcontract source selection if any part of its organization submits a proposal. Since BAE was the integrator of the hit avoidance system—of which the APS is a subset—and was submitting a proposal to be the APS developer, the lead systems integrator, Boeing Company, issued the final request for proposals and completed the source selection without BAE's involvement. The lead systems integrator chose the APS developer—the Raytheon Company—after all offerors were evaluated based on the same criteria contained in the request for proposals. Proposals from three companies were evaluated in the subcontractor selection process and all three were found to be comparable in the areas of cost, management/schedule, and past performance. The primary discriminating factor became technical merit. Based on input from the source selection evaluation team and source selection advisory council, the source selection executive decided that the Raytheon vertical launch concept would be more likely to meet all the APS requirements, even though it was based on less mature technology than other proposals. In March 2006, the APS contract was awarded to Raytheon.

The APS development contract required the winner of the subcontractor selection to perform a trade study that would identify and assess APS alternatives and select the best design for further development from among the competing alternatives. Even though the role played by Raytheon in the trade study was in accordance with its contract, the rationale for having the trade study follow the source selection is not entirely clear. While the trade study applied a consistent methodology to all alternatives before selecting Raytheon's preferred design as the best solution, this was a likely outcome given that the selection of Raytheon as the APS developer was based largely on this design concept. According to the study documentation, only one of the seven alternatives evaluated was less technologically mature than the vertical launch concept at the time the study was conducted. However, in assessing it against the weighted criteria, vertical launch scored the highest in all categories except risk. The study concluded that the vertical launch concept would be a high-payoff approach, albeit at a high risk. The Army estimated that, despite the immaturity of this APS, it could be available for prototype delivery to current force vehicles in fiscal year 2009 and tested on a FCS manned ground vehicle in 2011. This may be an optimistic estimate as the FCS manned ground vehicles are in the early stages of development.

Both the Army and the lead systems integrator were extensively involved in the APS subcontractor selection and the trade study. The Army FCS

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program officials were active participants in the source selection evaluation team and source selection advisory council and concurred in the final selection of the APS developer. Army FCS officials, as well as technical experts from Army research centers, were members of the trade study technical team and also concurred in the choice of the vertical launch design. Lead systems integrator officials were members of the source selection evaluation team and, with the Army's concurrence, made the source selection of Raytheon as the APS developer. In addition, the lead systems integrator participated in the trade study and was one of the trade study members who recommended the vertical launch approach.

The process followed by OFT to meet the urgent needs of the Central Command included a simpler evaluation of active protection systems with potential for near-term fielding and then centered on the results of physical testing of the most mature of the candidate APS systems, the Trophy. Decisions on how to proceed with the Trophy system involved considerable disagreement between OFT and the Army. While the testing of Trophy had a high success rate, the Joint Rapid Acquisition Cell recommended that the Central Command defer fielding the Trophy, based in part on the recommendations of the Army, which believed that the testing was not realistic and the Trophy's integration on the platform would delay fielding of other useful capabilities by at least 6 to 14 months. Further, the Army estimated that it would take 5 years to integrate and field Trophy on other current force manned ground vehicles. OFT officials recommended that additional testing of Trophy be conducted to answer the questions raised by the Army, but the Joint Rapid Acquisition Cell funding for further testing of the Trophy by OFT ceased after the Joint Rapid Acquisition Cell decision.

Because of the likelihood that the Army will introduce APS into its forces, we recommend that the Secretary of Defense support additional testing and demonstration of near-term APS systems on the Full Spectrum Effects Platform or similar vehicles to, at a minimum, help develop tactics, techniques, procedures, and concepts of operations for both near-term and long-term active protection systems.

In commenting on a draft of this report, DOD did not agree with our recommendation that it support additional testing and demonstration of near-term active protection systems on the Full Spectrum Effects Platform that could respond to the Central Command's need. It stated that there are no active protection systems mature enough at this time to integrate on this vehicle, regardless of any additional testing and demonstration efforts. DOD also stated that it continues to pursue active protection, citing its



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efforts with the vertical launch system for use on the FCS, among other things. However, we believe that testing near term active protection systems on the Full Spectrum Effects Platform or similar vehicles is valuable for answering remaining questions about such systems and future systems. This is particularly important given the likelihood that the Army will field some form of APS to its forces. We have broadened our recommendation to capture the value of continued testing of near-term APS for tactics, techniques and procedures and concepts of operations.

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## Background

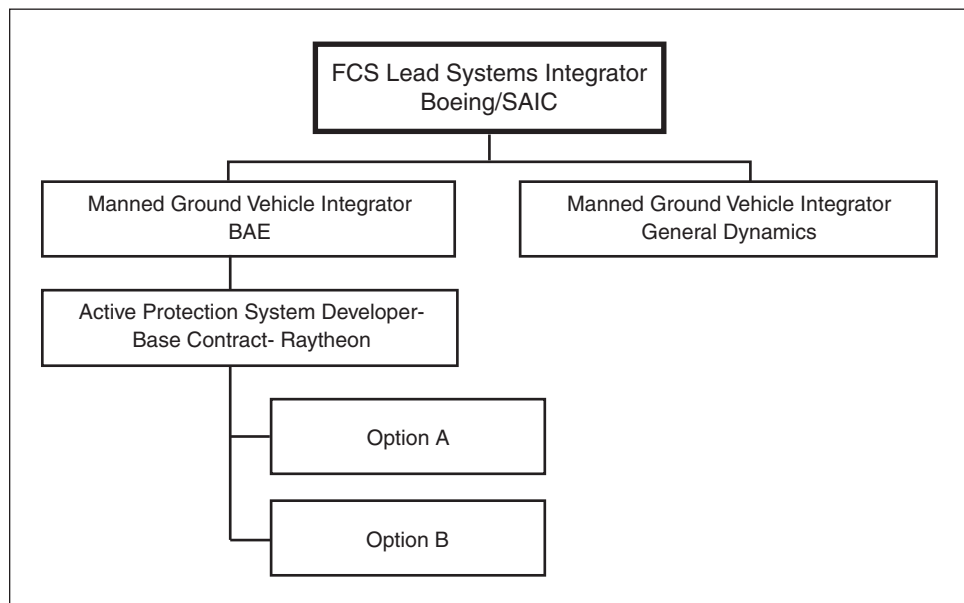
The FCS concept is designed to be part of the Army's Future Force, which is intended to transform the Army into a more rapidly deployable and responsive force that differs substantially from the large division-centric structure of the past. The FCS family of weapons is now expected to include 14 manned and unmanned ground vehicles, air vehicles, sensors, and munitions that will be linked by an advanced information network. Fundamentally, the FCS concept is to replace mass with superior information—allowing soldiers to see and hit the enemy first rather than to rely on heavy armor to withstand a hit. The Army envisions a new way of fighting that depends on networking the force, which involves linking people, platforms, weapons, and sensors seamlessly together in a system of systems.

Within the FCS program, eight types of manned ground vehicles are being developed, each having a common engine, chassis, and other components. One of the other common components is a hit avoidance system that features a set of capabilities to detect, avoid, and/or defeat threats against the manned ground vehicles. One of its subsystems is the APS, which is intended to protect a vehicle from attack by detecting a threat in the form of an incoming round or rocket propelled grenade (threat) and launching an interceptor round from the vehicle to destroy the incoming weapon. An APS system consists of a radar to detect the incoming weapon, a launcher, an interceptor or missile, and a computing system.

The Army has employed a management approach for FCS that centers on a lead systems integrator to provide significant management services to help the Army define and develop FCS and reach across traditional Army mission areas. Boeing, along with its subcontractor, the Science Applications International Corporation (SAIC), serves as the lead systems integrator for the FCS system development and demonstration phase of acquisition, which is expected to extend until 2014. The lead systems integrator has a close partner-like relationship with the Army and its responsibilities include requirements development, design, and source

selection of major system and subsystem subcontractors. In the case of APS, the first-tier subcontractors are the manned ground vehicle integrators, BAE and General Dynamics Land Systems, who are responsible for developing individual systems. BAE was designated the hit avoidance integrator, a role that covers more than active protection, and was responsible for awarding the subcontract to the APS developer. This subcontract has three elements: a base contract, option A to support the current force (the short-range solution) and option B to support the FCS manned ground vehicles (short- and long-range solution). Figure 1 illustrates these relationships.

**Figure 1: FCS APS Major Players**



Source: Army (data), GAO (presentation).

A separate initiative involving active protection resulted from a Joint Urgent Operational Needs Statement,<sup>2</sup> issued by Central Command and the Multi-National Corps in Iraq in April of 2005, which requested 14 special-equipped vehicles with a host of distinctive capabilities, one of which was

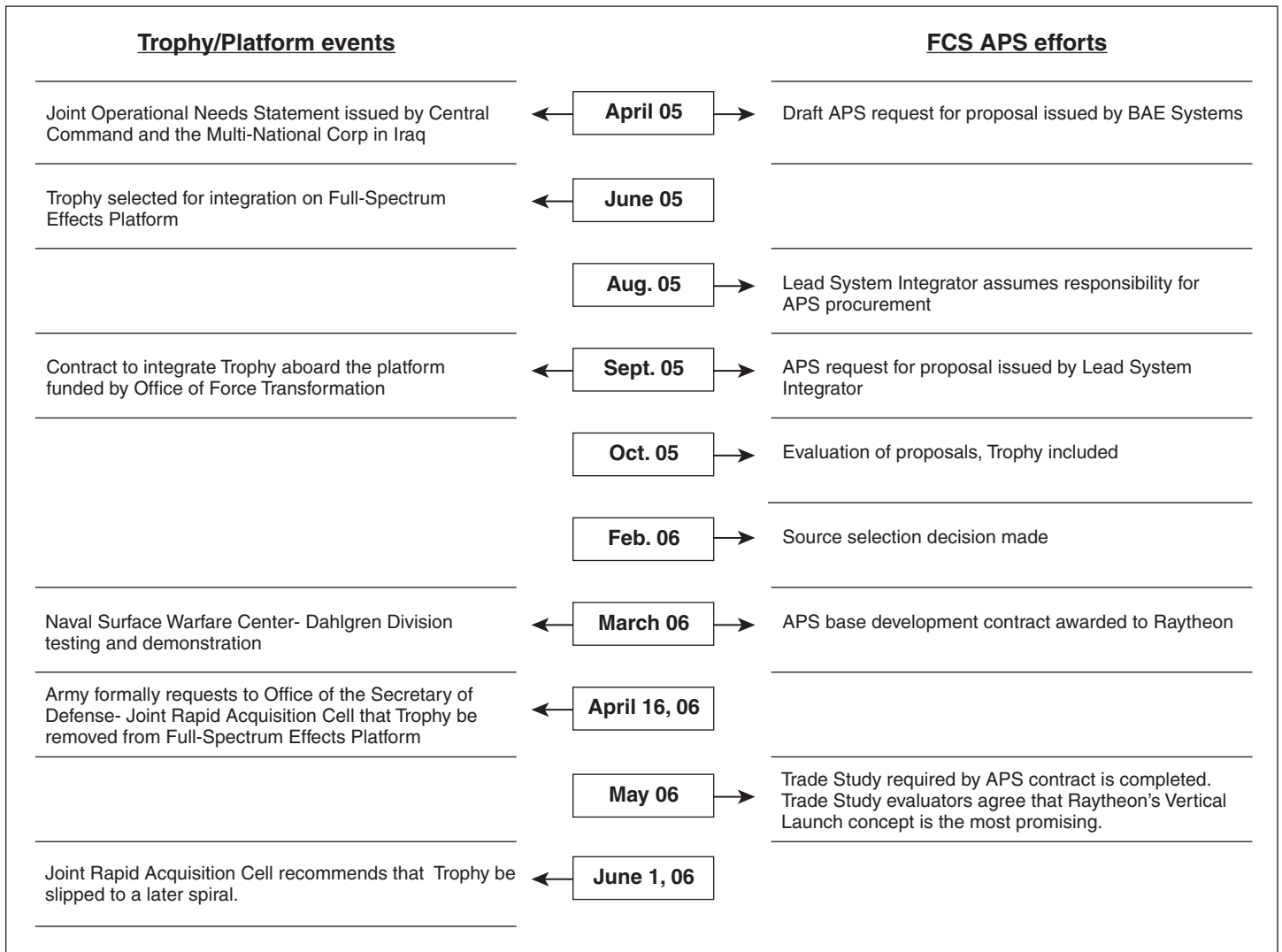
<sup>2</sup> A joint urgent operational need is a need that can be considered life or combat-mission-threatening based on unforeseen military requirements that must be resolved in days, weeks, or months. Chairman of the Joint Chiefs of Staff Instructions 3470.01, Rapid Validation and Resourcing of Joint Urgent Operational Needs (JUONS) in the Year of Execution, July 15, 2005.

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an APS. The need statement called for a capability to field a combination of near-term technologies that would be useful in conducting force protection missions, reconnaissance and crowd control in Iraq and an evaluation of an active protection capability against rocket-propelled grenades as part of this suite of capabilities. To respond to this need statement, the Joint Rapid Acquisition Cell, a group within the Office of the Secretary of Defense (OSD) that seeks solutions to urgent needs and focuses on near-term or off-the-shelf equipment to meet these needs, provided funding to the Army, which worked with the OFT to evaluate various technologies, including an APS, for inclusion on the vehicles. The OFT was also an office within the OSD, and its role was to examine unanticipated needs and experiment with innovative technologies that could be used to meet warfighter needs.

Both the process for evaluating APS sources and concepts to meet FCS needs and the urgent needs of the Central Command occurred nearly simultaneously, as shown in figure 3.

**Figure 2: Timelines for OFT and Army Processes for Evaluating Active Protection Systems**



Source: Army and OFT (data), GAO (presentation and analysis).

As can be seen in figure 3, many events took place at the same time. The lead systems integrator for FCS completed its subcontractor selection for APS shortly before decisions were made on the near term system being considered to meet the Central Command need. The Trophy system was evaluated as a candidate system in both processes.

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## APS Source Selection Avoided Organizational Conflicts of Interest

In choosing the developer for the APS system, the FCS lead systems integrator, with Army support and concurrence, conducted a source selection and followed the FCS lead systems integrator subcontract provisions for avoiding organizational conflicts of interest. The purpose was to select the subcontractor for the APS that would be best able to develop the overall APS architecture to address the FCS requirements to defeat the short- and long-range antiarmor threats as well as meet the current force needs for defeating short-range rocket-propelled grenade attacks. The subcontractor selected would support the hit avoidance integrator in integrating APS technology into the FCS manned ground vehicles and also apply this architecture to the Army's current force. The contract included two options that were to supply the specific design for the APS system: Option A for the short-range APS for the current force; and Option B for the short- and long-range solution for the FCS. These options would be awarded later, based on the results of trade studies subsequently performed.

To protect against organizational conflicts of interest, contracts between the FCS lead systems integrator and its subcontractors preclude a subcontractor from conducting or participating in a source selection for other FCS subcontracts if any part of its organization submits a proposal.<sup>3</sup> Under normal circumstances, since the APS would be part of the hit avoidance system of the FCS manned ground vehicles, the hit avoidance integrator, BAE, would have had the primary responsibility to issue the requests for proposals, conduct the source selection evaluation, and award the contract. In this capacity, BAE issued a draft request for proposals for the APS in April 2005. When the firm subsequently decided to submit a proposal on the APS subcontract, it was required, under the FCS lead systems integrator subcontract organizational conflict of interest provisions, to notify the lead systems integrator, Boeing, of its intention. BAE did so and the lead systems integrator reissued the request for proposals for APS in September 2005 and assumed the source selection responsibilities. BAE submitted its proposal but then had no further role in the evaluation of proposals or the actual source selection. After the source

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<sup>3</sup>The FCS lead systems integrator contract required that an organizational conflict of interest provision be included in the subcontracts under the FCS lead systems integrator contract and flowed down to all lower level subcontract tiers. The lead systems integrator developed a specific organizational conflicts of interest clause applicable to all subcontract tiers under this contract. Additionally, the lead systems integrator contract provided that pursuant to the FAR 9.5, subcontractors could neither prepare RFP documents nor conduct or participate in a source selection if any part of its organization submits a proposal.

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selection was complete, the lead systems integrator transferred contract responsibility to BAE, and BAE assumed the responsibility for awarding and administering the APS contract.

From our review, the documentation from the APS source selection process shows that (1) no officials from the offering companies participated in the source selection process, and (2) all offerors were evaluated based on the same criteria contained in the request for proposals.<sup>4</sup> In response to this request for proposals, four proposals were received. Three proposals were considered competitive, while the fourth was eliminated from consideration as it was considered “unsatisfactory” in technical merit and its architectural approach did not meet the requirements. Proposals from the remaining three companies—BAE, Raytheon, and General Dynamics Land Systems—were evaluated in the source selection process and no officials from these companies were on the evaluating or selecting teams. The source selection evaluation team consisted of 53 members, with 27 lead systems integrator representatives and 26 government representatives, including personnel from the FCS program manager’s office, Army research centers, and the Defense Contract Management Agency. After evaluating each of the proposals against the criteria spelled out in the request for proposals, the source selection evaluation team made its recommendation to the lead systems integrator source selection executive, who accepted its recommendation.

Our review of the documentation shows that the criteria were ranked in order of importance, with technical merit considered most important, then cost, management/schedule and finally past performance. The technical merit criteria were divided into six sub-factors: systems engineering and architecture; expertise in APS technologies; simulation, modeling and test; fratricide and collateral damage; specialty engineering; and integration capability. Cost criteria were based on the realism, reasonableness, completeness, and affordability of the proposal. Management/ schedule criteria included such areas as expertise and experience in key positions. The past performance risk rating category was based on whether the respondents’ past performance raised doubts about their being able to perform the contract.

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<sup>4</sup>We reviewed the source selection documentation for reporting purposes and did not conduct a legal review of the evaluation or selection decision.

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Since all three proposals were deemed comparable in the areas of cost, management/schedule, and past performance, the primary discriminating factor became technical merit. According to the evaluation documentation, the technical merit scores were assessed based on whether the proposal demonstrated that the contractor understood the requirements and on its approach to meeting these requirements in each of the six technical merit sub-factors. Also, part of the technical score was a proposal risk evaluation, defined as the degree any proposal weaknesses could cause disruption of schedule, increase in cost, or degradation in performance.

While the source selection's stated purpose was to choose the company best able to develop the APS and not a specific design, each proposal used a specific APS system as an "artifact" to illustrate how they intended to meet the requirements. Even though, in theory, one company could have been chosen as the APS developer while another company's preferred design could have been selected for development, much of the source selection assessment of technical merit was based on the "artifact" used for illustration. For example, in the technical merit category of APS expertise, the source selection evaluation of Raytheon states that "the vertical launch concept solves several design and integration problems." Similarly, the BAE evaluation in the criteria of APS expertise states that "the proposed long-range countermeasure... design has effectiveness against the full spectrum of threats." The General Dynamics Land System's evaluation discusses the relatively high technology readiness level (TRL)<sup>5</sup> of the "proposed Trophy system." Therefore, while each company's proposed solution was not the only aspect of the proposals to be evaluated, the evaluation documentation shows that the technical merit category was a key factor in the evaluation.

The source selection evaluation team decided that the BAE and Raytheon proposals had the highest technical merit. BAE had a lower-risk approach and its solution had been tested in a relevant environment: however, the source selection evaluation team stated that this low-risk approach could prevent BAE from considering higher-risk options that would enable them to meet the full range of the performance requirements, such as protection from top-attack weapons. In addition, the source selection evaluation team

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<sup>5</sup>Technology readiness levels characterize the readiness of technologies for hand-off to project implementers. Nine levels are defined, representing concepts from fundamental research level (TRL 1) through technologies fully qualified and demonstrated (TRL 9).

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determined that, while both Raytheon and BAE could develop the design presented in the BAE proposal, Raytheon would have the advantage if the vertical launch design was chosen. The evaluation team concluded that the Raytheon approach would have the best chance of meeting all the requirements. Based on the team's recommendation, the lead systems integrator selected Raytheon. The integrator accepted the higher risk because it concluded that the Raytheon proposal had excellent technical merit and the firm would be better able to develop the vertical launch technology, if that were the design decided upon in the trade study.

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## Trade Study Used Consistent Method in Reaffirming Vertical Launch Concept

The APS development contract required the winner of the source selection to perform a trade study identifying and assessing competing APS alternatives. The trade study used a methodology consistent with Army guidance to evaluate all alternatives, ultimately selecting Raytheon's vertical launch as the best design. According to the Army and the lead systems integrator, conducting the trade study after choosing the APS subcontractor could have resulted in selecting a different concept than Raytheon's vertical launch design. However, in our view, this possibility appears remote given the selection of Raytheon as APS developer was based largely on the technical merits of its vertical launch design and the fact that it would be best able to develop that design.

The development contract's terms required the source selection winner to perform a trade study that would identify and assess APS alternatives and select an APS design from among competing alternatives. Therefore, once Raytheon won the development contract in March 2006, it was required to conduct the trade study rather than simply develop its own design. Since the trade study was not a source selection, FAR contract provisions regarding organizational conflicts of interest did not apply and Raytheon was free to participate in the study as the responsible contractor. The trade study's specific objective was to choose a single short-range APS architecture (launcher and interceptor) that best met active protection requirements for FCS manned ground vehicles, with consideration for application to the current force. The study was conducted in May 2006 and Raytheon's vertical launch concept was selected as the design.

Based on the trade study documentation, the study was conducted using a methodology prescribed by Army guidance and this methodology was applied consistently to all APS alternatives. Seven alternatives survived a screening process and were then evaluated against a set of weighted criteria. The study concluded that Raytheon's vertical launch was the best design approach.



According to general Army guidance for trade studies, steps in the trade study process should include such elements as incorporating stakeholders, identifying assumptions, determining criteria, identifying alternatives, and conducting comparative analyses. The APS trade study process consistently applied such methodology to all APS alternatives by using separate, independent roles for a technical team and stakeholders; operating under a set of assumptions; using validated, protected technical data on each alternative; having a screening process to filter out non-viable alternatives; and using a set of weighted criteria to assess alternatives that survived the screening process.

The trade study was performed by a technical team and stakeholders—each having separate roles and operating independently from one another. The technical team provided technical input and expertise to the stakeholders, who were the voting members of the study and made the final selection. The technical team, 21 members from industry and government as shown in table 1, included individuals who were subject matter experts as well as those from organizations participating in development of the short-range APS. Raytheon had 11 members on the technical team—the most from any single organization. The Army stated that this representation included administrators and observers and occurred because Raytheon had been designated APS developer, was thus required to conduct the trade study, and could gain knowledge from attending subject matter experts.

**Table 1: Composition of APS Trade Study Technical Team**

Industry	Government
Boeing/SAIC	(1) U.S. Army Program Manager, FCS (1)
BAE	(1) U.S. Army Armament Research, Development, and Engineering Center (1)
General Dynamics Land Systems	(3) U.S. Army Material Systems Analysis Activity (1)
Raytheon	(11) Department of Energy - Idaho National Lab (2)

Source: Army (data), GAO (presentation and analysis).

The stakeholders made the final selection. The composition and number of stakeholders are shown in table 2. The stakeholders were program leads from the Army, lead systems integrator, and subcontractors responsible for integrating the FCS manned ground vehicles. According to the Army, Raytheon’s APS program manager was included as a stakeholder because

Raytheon as developer had responsibility for developing the design chosen by the trade study process.

**Table 2: Composition of APS Trade Study Stakeholders**

Industry	Government
Raytheon	(1) U.S. Army Program Manager, FCS (1)
BAE	(2) U.S. Army Training and Doctrine Command (1)
General Dynamics Land Systems	(2) U.S. Army Program Executive Office for Ground Combat Systems (1)
Boeing/SAIC	(1)

Source: Army (data), GAO (presentation and analysis).

The technical team and stakeholders operated the trade study under assumptions that set parameters for screening and evaluating each alternative. These assumptions were tied to such areas as performance and threat. Additionally, they conducted the study using data that was previously validated and remained protected throughout the study's course. The primary source of the data was the Army Research, Development, and Engineering Command's APS database, which contained data gathered and validated by the Command's subordinate labs. This data was protected by third parties, including the Department of Energy's Idaho National Lab, to ensure it was not changed during the study.

The technical team used initial screening processes to eliminate four alternatives and identify seven viable alternatives for further assessment. The screening process filtered out the four alternatives that could not meet one or both of two criteria: (1) ability to grow to meet 360-degree hemispherical requirements, and (2) ability to be procured within a program schedule that would meet the need for prototype delivery of a short-range solution to the current force in fiscal year 2009. The seven alternatives that survived the screening process are shown in table 3, along with the respective government organizations and industry associated with each.

**Table 3: APS Concepts Considered in Trade Study**

<b>Government organization/industry</b>	<b>Alternative</b>
U.S. Army Aviation and Missile Research, Development, and Engineering Center/Boeing	Close-In Active Protection System
U.S. Army Aviation and Missile Research, Development, and Engineering Center/Boeing	Close-In Active Protection System II
U.S. Army Tank and Automotive Research, Development, and Engineering/BAE	Close-In Countermeasure
U.S. Army Tank and Automotive Research, Development, and Engineering/Chang Industries	Full Spectrum Close-In Layered Shield
U.S. Army Tank and Automotive Research, Development, and Engineering/BAE and Northrup Grumman	Integrated Army Active Protection System
Israel/Rafael and General Dynamics Land Systems	Trophy
U.S. Army Program Manager, FCS/Raytheon	Vertical Launch

Source: Army (data), GAO (presentation and analysis).

The technical team assessed the seven alternatives against a set of five weighted criteria. According to the Army, these were the same top-level criteria mandated in all FCS trade studies, and their weights were assigned by FCS chief engineers. Table 4 defines each of the criteria and provides information on respective weights.

**Table 4: Top-Level Criteria and Associated Weights**

<b>Criteria</b>	<b>Description</b>	<b>Weight</b>
Performance	Survivability, logistics, and reliability	35%
Cost	Average unit production cost for fitting 500 vehicles	25%
Burdens	Includes signature, weight, volume, power, and integration complexity	20%
Risk	Technical, schedule, and cost risk	15%
Growth potential	System growth potential to counter full spectrum of threats	5%

Source: Army (data), GAO (presentation and analysis).

The vertical launch concept scored highest in every category of criteria except risk. The Army indicated that the concept had about one-third better overall weighted performance than the other alternatives. Army officials described the vertical launch design as having technical

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advantages over the other alternatives—including the need for less space, weight, and power—as well as cost benefits.

The Army and lead systems integrator officials told us that the trade study could have resulted in the selection of a design other than Raytheon's. They also stated that, had this occurred, Raytheon as APS developer would have been required to develop this design rather than the vertical launch. While in theory the APS source selection chose a developer and the trade study chose the design to develop, in reality it is difficult to separate the trade study results and the source selection decision. In our view, in both the source selection and trade study, criteria related to technical aspects of the designs were deciding factors. Considering that the source selection evaluation relied on artifacts representing specific systems—and Raytheon won the source selection based in large part on the technical merit of its artifact—it seems unlikely that the APS trade study would have resulted in the selection of any system other than Raytheon's vertical launch.

Although the trade study concluded that vertical launch was a high-payoff approach, it also noted that it was a high risk due to its low technology maturity. At the time of the trade study, as shown in table 5, the vertical launch was less technologically mature than the other alternatives except for one.

**Table 5: Technology Maturity Levels of APS Alternatives as of May 2006**

<b>Alternative</b>	<b>Technology maturity</b>
Close-In Active Protection System	6
Close-In Active Protection System II	3
Close-In Countermeasure	6
Full Spectrum Close-In Layered Shield	6
Integrated Army APS	6
Trophy	6
Vertical Launch	5

Source: Army (data), GAO (presentation and analysis).

The Army expects the design to reach TRL 6 (system model or prototype demonstration in a relevant environment) by August or September 2007. The Army expects the vertical launch concept to be available for prototype delivery to current force combat vehicles in fiscal year 2009 and for testing on a FCS vehicle in 2011. These estimates appear optimistic. At a TRL 5,

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the vertical launch will require additional technology development and demonstration before it is ready for either application. Also, the FCS vehicles have not been fully developed yet. Assuming all goes as planned, most FCS vehicle prototypes are expected to be available in 2011 for developmental testing. As we noted in our March 2007 report,<sup>6</sup> the Army has in general been accepting significant risks with immature technologies for the FCS program, coupled with compressed schedules for testing and evaluating prototypes.

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## Army and Lead Systems Integrator Had Extensive Roles in APS Subcontractor Selection and Trade Study

The Army and the lead systems integrator were both extensively involved in preparing for and conducting the APS subcontractor selection and the trade study. Prior to the selection, FCS program officials assisted in APS requirements development and reviewed and approved the scope of work, schedule, and evaluation criteria for the request for proposals. After the proposals were received, FCS program officials, technical experts from various Army research centers, representatives of the Tank-Automotive and Armaments Command and the Training and Doctrine Command were active participants in the selection evaluation team and reviewed the proposals along with the lead systems integrator members. The Source Selection Advisory Council, who advise the Source Selection Executive, provided oversight to the evaluation team and also had representatives from the FCS program manager's office and the Army research community. Similarly, Army FCS officials, as well as technical experts from Army research centers, were members of the trade study technical team and also concurred in the choice of the vertical launch concept. The co-lead of the trade study was an FCS official. The lead systems integrator's office assumed responsibility for the selection process, was the selection executive, and made the final choice of an APS developer. In addition to its lead role in the APS subcontractor selection, the lead systems integrator was represented on the trade study technical team and was one of the stakeholders.

As our previous body of work on the FCS program has shown, the Army's participation in the APS subcontractor selection and trade study is consistent with the Army's general approach to FCS. Army leadership set up the FCS program in such a way that it would create more competition and have more influence over the selection of suppliers below the lead

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<sup>6</sup>GAO, *Defense Acquisitions: Key Decisions to Be Made on Future Combat System*, GAO-07-376 (Washington D.C.: Mar. 15, 2007).

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systems integrator. In setting up FCS, Army leadership noted that traditionally, once the Army hired a prime contractor, that contractor would bring its own supplier chains. The Army was not very involved in the choice of the suppliers. In FCS, the Army called for the lead systems integrator to hold a competition for the next tier of contractors. The Army had veto power over these selections. In addition, the Army directed that the lead systems integrator employ integrators at lower levels in the program, for high-cost items such as sensors and active protection systems and the Army has been involved with these selections. These integrators were also to hold competitions to select suppliers for those systems. This strategy was designed to keep the first tier of contractors from bringing their own supplier chains and pushed competition and Army visibility down lower in the supplier chain. The fact that the decisions on the APS subcontractor selection and trade study lend themselves to after-the-fact examination is due in part to the Army's focus on competition at lower supplier levels on FCS.

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## OFT Process for Evaluating APS Was More Test-Based and Near-Term Oriented

The process followed by OFT to meet the urgent needs of the Central Command was characterized by a simpler evaluation of active protection systems with potential for near term fielding, followed by actual physical testing of the APS candidate system that the OFT considered most technically mature, the Trophy. The Army's Program Manager's Office for Close Combat Systems was also involved in this evaluation. While the testing of Trophy had a high success rate, the Joint Rapid Acquisition Cell decided to defer fielding the Trophy based, at least in part, on the recommendations of the Army that the testing was not realistic and the Trophy's integration on the platform would delay fielding of other useful capabilities. OFT officials did not agree with the Army's position and thought the system's success in testing indicated it should be further evaluated.

To meet the Central Command's need, OFT began an effort, the Full-Spectrum Effects Platform, to incorporate and test various improvements for potential application to existing military vehicles such as the Stryker. The platform itself is a modified Stryker vehicle.<sup>7</sup> The program was divided into spirals: spiral 0 was to evaluate the synergy of the different systems,

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<sup>7</sup>The OFT had initiated a program called Project Sheriff in 2004, prior to the Central Command's need statement, to address urgent warfighter needs for lethal and non-lethal weapons, and force protection. After the needs statement, this evolved into the Full-Spectrum Effects Platform effort.

including the APS, on the vehicle and to compile lessons learned to aid in future concepts of operations, development and integration. Spiral 1 was intended to field a limited number of such systems to current forces in-theater in 2007, for purposes of an operational assessment of the various capabilities. The Full Spectrum Effects Platform is not part of or associated with FCS.

OFT, in association with the Naval Surface Warfare Center, evaluated six candidate APS systems. Army representatives from the Program Manager, Close Combat Systems were also involved in this evaluation. The six candidate systems evaluated are shown in table 6.

**Table 6: APS Candidate Systems and Developers**

<b>Candidate</b>	<b>Developer</b>
Close-in Active Protection System	Aviation and Missile Research, Development and Engineering Center
Close-in Countermeasure	British Aerospace (formerly United Defense)
Canister-Launched Area Denial System	Northrop Grumman
Tactical Rocket-Propelled Grenade Airbag Protection System	Innovative Survivability Technologies
Full-Spectrum Close-in Layered Shield	Chang Industries
Trophy	Rafael/General Dynamics Land Systems

Source: OFT.

These systems were evaluated because the OFT and Navy and Army officials considered them to be the most promising APS solutions available within the required schedule. They evaluated each system based on such criteria as the feasibility of the operational concept, its cost and schedule factors, as well as its weight, size, and power requirements. Trophy was selected as the most promising system because it was the most technically mature system and was being developed by Israeli defense forces that had done initial work to integrate it on a light armored vehicle.

OFT subsequently sponsored tests of the Trophy APS as part of the Full-Spectrum Effects Platform at Naval Surface Warfare Center in Dahlgren, Virginia. A representative from the Army's Program Manager, Close Combat Systems, was part of the oversight team for these tests. In these test firings, the Trophy APS did well, destroying 35 of 38 incoming rocket-propelled grenades. However, the process for deciding how to proceed based on the test results was not agreed to in advance. A disagreement

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subsequently arose between OFT and the Army Close Combat System officials on how best to proceed from the testing.

Although the tests were not designed to represent the Trophy's capabilities in a realistic operational environment, OFT officials concluded that Trophy showed enough promise that they recommended continued testing to demonstrate its capabilities under various conditions. These officials estimated that an additional \$13 million would cover the cost for this testing. They believed that Trophy could be integrated in the near term on existing light-armored vehicles and meet the urgent need for an immediate APS capability.

The Army officials disagreed with OFT's assessment that further testing of Trophy for inclusion on the Full Spectrum Effects Platform was justified. According to the Army officials, Trophy was not tested in a realistic environment for collateral damage or effectiveness. They believed that it would not be sufficiently tested for operational and safety issues within the time period required for the first spiral of the Full Spectrum Effects Platform. A delay in its integration on the Platform would delay, by at least 6 to 14 months, demonstration of other potentially useful capabilities, that could be immediately incorporated. Further, the Army estimated that it would take 5 years to integrate and field Trophy on other current force manned ground vehicles. The Army recommended to the Joint Rapid Acquisition Cell that the Trophy APS be excluded from Spiral 1 of the Full-Spectrum Effects Platform. In lieu of putting this technology in the field, the Army recommended that slat armor<sup>8</sup> be incorporated on Spiral 1, since it has been effective in defeating the current rocket-propelled grenade threat. OFT officials disagreed, reasoning that although the use of slat armor on the current force has seemed to mitigate the effects of the rocket-propelled grenades currently in use, improved munitions will soon be available, and the slat armor will no longer be effective against these threats. They believed that the Trophy should be tested further in order to answer the questions raised by the Army and to provide insight into its capabilities. OFT officials based their position on the Trophy's success in these tests, its high level of technical maturity when compared to other active protection systems, and the criticality of the need.

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<sup>8</sup>Slat armor forms a metal frame barrier on the front of the vehicle that detonates the rocket-propelled grenade away from the vehicle, preventing it from boring through the vehicle and causing damage and injury.



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The Joint Rapid Acquisition Cell presented this information to Central Command and recommended slipping the active protection capability to a later platform spiral, once it was more mature. Currently, there are no plans for further evaluation of active protection for future platform spirals. Upon the removal of the Trophy APS system from the Full-Spectrum Effects Platform vehicle, the Joint Rapid Acquisition Cell discontinued funding for further testing and evaluation of the Trophy. The disagreement between Army and OFT officials notwithstanding, we did not find information that would challenge the decision to defer the introduction of the Trophy on light-armored vehicles. On the other hand, the 5 years the Army estimated would be needed to integrate the comparatively mature Trophy system on the existing Stryker vehicle does not appear consistent with its estimates that the less mature vertical launch system could be ready for prototype delivery on Strykers in 2 years and on the yet-to-be developed FCS prototypes in 3 years.

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## Conclusions

The FCS lead systems integrator, with support from the Army, followed a consistent and disciplined process in both selecting Raytheon to develop the APS for FCS and in conducting the trade study and followed the lead systems integrator subcontract and FAR provisions for avoiding organizational conflicts of interest. While the role played by Raytheon in the trade study was in accordance with its contract and thus not improper, the rationale for having the trade study follow the source selection is not entirely clear. The purpose of the trade study was to select the best concept; yet, the source selection process that preceded it had, in fact, chosen Raytheon primarily on the technical merits of its vertical launch design concept. It was thus improbable that the trade study would reach a different conclusion. Both the Army and the lead systems integrator were closely involved throughout the source selection and trade study processes and concurred in the selection of Raytheon's APS concept.

The process for evaluating the Trophy system to meet the urgent needs of the Central Command was different. It centered more directly on the results of physical testing, followed a less-disciplined decision-making process, and was characterized by considerable disagreement between OFT and the Army. While the decision to defer the use of the Trophy on fielded vehicles appears prudent in light of the limited realism of the testing, the promising results of the testing likewise appeared to warrant additional testing of the Trophy system to either confirm or dispel potential risks in the use of APS capabilities. Discontinuing all testing of the Trophy systems may thus have been premature, particularly in light of

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the need to better understand tactics, techniques and procedures and concepts of operations for both near-term and long-term applications.

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## Recommendations for Executive Action

Because of the likelihood that the Army will introduce APS into its forces, we recommend that the Secretary of Defense support additional testing and demonstration of near-term APS systems on the Full Spectrum Effects Platform or similar vehicles to, at a minimum, help develop tactics, techniques, procedures, and concepts of operations for both near-term and long-term active protection systems.

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## Agency Comments and Our Evaluation

DOD provided us with written comments on a draft of this report. The comments are reprinted in appendix II. DOD did not concur with our recommendation. DOD also provided technical comments, which we incorporated where appropriate.

DOD did not concur with our recommendation that the Secretary of Defense support additional testing and demonstration of near-term active protection systems on the Full Spectrum Effects Platform that could respond to the Central Command's need. It stated that the original decision in May 2006 that delayed delivering Full Spectrum Effects Platform capabilities due to technical development and performance risks remains true today. DOD added that there are no active protection systems mature enough at this time to integrate on a Full Spectrum Effects Platform regardless of any additional testing and demonstration efforts. This represents a much more decided opinion than was rendered at the time of the OFT tests. At that time, Army officials believed that the Trophy would not be sufficiently tested for operational and safety issues in time for the first spiral of the Full Spectrum Effects Platform. OFT officials believed that the Trophy should be tested further to answer the questions raised by the Army and to provide insight into its capabilities. Ultimately, the Joint Rapid Acquisition Cell recommended slipping the active protection capability to a later spiral of the Full Spectrum Effects Platform. This was the basis for our recommendation for additional testing of near-term active protection systems on the Full Spectrum Effects Platform.

DOD stated that it continues to pursue active protection, citing the Army's vertical launch system for FCS. As stated in our report, this system is technically immature and the Army's estimates for testing it appear optimistic. According to the Institute of Defense Analysis, the vertical launch system is ambitious, with much enabling technology not yet

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demonstrated. Given the criticality of active protection for the FCS manned ground vehicles, additional testing of near-term active protection systems could provide valuable insights into operations and tactics that would benefit future applications, such as FCS. DOD noted that the Trophy system is being tested on the Wolf Pack Platoon Project, an OSD Rapid Reaction Technology Office (formerly OFT) effort. However, this project is not directed toward development of APS tactics, techniques, procedures, or concepts of operations. In addition, it will not include testing against live targets.

Testing near-term active protection systems on the Full Spectrum Effects Platform or similar vehicles is valuable for answering remaining questions about such systems and to provide insights for the employment of future systems. This is particularly important given the likelihood that the Army will field some form of APS to its forces. We have broadened our recommendation to capture the value of continued testing of near-term APS for tactics, techniques and procedures and concepts of operations.

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Please contact me on (202) 512-4841 if you or your staff has any questions concerning this report. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report.



Paul L. Francis  
Director  
Acquisition and Sourcing Management

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# Appendix I: Scope and Methodology

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To develop the information on the U.S. Army's decision to pursue a new APS system under the FCS program, we interviewed officials of the Office of the Assistant Secretary of the Army (Acquisition, Logistics and Technology); the Tank-Automotive and Armaments Command; the Joint Rapid Acquisition Cell; the Office of Force Transformation; the Naval Surface Warfare Center (Dahlgren Division); the Program Manager for the Future Combat System (Brigade Combat Team); and the Future Combat System Lead Systems Integrator.

We reviewed the APS subcontractor selection documentation, including the APS request for proposal, current force and FCS operational requirements documents, subcontract proposals, criteria used to rate those proposals, and the APS development contract to determine if procedures for avoiding organizational conflicts of interest were followed and how the APS subcontractor was selected. In addition, we held discussions with key Army officials and lead systems integrator representatives regarding this process and their roles in it. To determine why the trade study was conducted after source selection, we reviewed the trade study process and results and Army guidelines for conducting trade studies. To identify the roles played by both the Army and lead systems integrator in the selection of an APS, we reviewed documentation concerning their roles in these processes. We also reviewed these materials to determine whether consideration was given to a separate APS solution for current forces and, in conjunction with this issue, we reviewed test reports and other documentation and discussed the testing of an alternative APS system, the Trophy, with the parties involved.

In evaluating the APS subcontractor selection and trade study processes, we did not attempt to determine if the best technical solution was chosen, but only if these processes followed lead systems integrator provisions for organizational conflicts of interest and used a consistent methodology for the trade study. We conducted our work between October 2006 and June 2007 in accordance with generally accepted government auditing standards.

# Appendix II: Comments from the Department of Defense



ACQUISITION,  
TECHNOLOGY  
AND LOGISTICS

OFFICE OF THE UNDER SECRETARY OF DEFENSE  
3000 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3000

JUN 4 2007

Paul L. Francis  
Director, Acquisition and Sourcing Management  
U.S. Government Accountability Office  
Washington, D.C. 20548.

Dear Mr. Francis:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-07-759, "DEFENSE ACQUISITIONS: Analysis of Processes Used to Evaluate Active Protection Systems," dated April 30, 2007 (GAO Code 120624).

The report recommends that the Secretary of Defense reconsider supporting additional testing and demonstration of near term Active Protection Systems' systems on the Full Spectrum Effects Platform (FSEP) that could respond to the Central Command's need.

The Department non-concurs with the GAO recommendation. The original decision in May of 2006 that delayed delivering FSEP capabilities due to technical development and performance risks remains true today. Our comments on the recommendation are enclosed.

The Department appreciates the opportunity to comment on the draft report. Technical comments were provided separately. For further questions concerning this report, contact Mr. Robert Maline at (703) 693-9414.

Sincerely,

David G. Ahern  
Director  
Portfolio Systems Acquisition

Enclosure:  
As stated



GAO DRAFT REPORT DATED APRIL 30, 2007  
GAO-07-759 (GAO CODE 120624)

**“DEFENSE ACQUISITIONS: ANALYSIS OF PROCESSES  
USED TO EVALUATE ACTIVE PROTECTION SYSTEMS”**

**DEPARTMENT OF DEFENSE COMMENTS  
TO THE GAO RECOMMENDATION**

**RECOMMENDATION:** We recommends that the Secretary of Defense reconsider supporting additional testing and demonstration of near term APS systems on the Full Spectrum Effects Platform that could respond to the Central Command’s need. (p. 21/GAO Draft Report)

**DoD RESPONSE:** Nonconcur. There are no Active Protection Systems (APS) mature enough at this time to integrate onto a Full Spectrum Effects Platform (FSEP) regardless of any additional testing and demonstration efforts. The recommendations of this report are not supported by the report findings. The Director, Joint Rapid Acquisition Cell, consulted with technical experts and U.S. Central Command before deciding that deferring Trophy (the Israeli Active Protection System) on the FSEP was a reasonable approach.

The Department continues to pursue Active Protection. In addition to the work on Active Protection System development spearheaded by Future Combat Systems, the Rapid Reaction Technology Office (formerly the Office of Force Transformation) is also testing the Trophy APS as part of the Wolf Pack Platoon Project. Additionally, the Defense Advanced Research and Programs Agency is developing potential systems and the Foreign Comparative Test Office is monitoring active protection systems.

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# Appendix III: GAO Contact and Staff Acknowledgments

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## GAO Contact

Paul Francis, (202) 512-4841

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## Acknowledgments

Other contributors to this report were Assistant Director William R. Graveline, Marie P. Ahearn, Beverly Breen, Tana Davis, Letisha Jenkins, Kenneth E. Patton, and Robert Swierczek.

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