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United States Government Accountability Office
Washington, DC 20548

December 16, 2010

Congressional committees

Subject: B-2 Bomber: Review of the Air Force's Decision to Change Extremely High Frequency Satellite Communications Antennas

The B-2 bomber is a low-observable, long-range strike aircraft capable of entering heavily defended areas to deliver both conventional and nuclear weapons. The B-2 currently uses an ultra high frequency (UHF) satellite communications system, but because of aging military satellites, the Air Force determined a new communications system was needed. As a result, the Air Force began an incremental acquisition approach for replacing the B-2's existing UHF satellite communications system with an extremely high frequency (EHF) communications capability. The first increment, which is expected to begin production in late fiscal year 2011, is designed to upgrade computer system speed and storage capacity. The second increment is expected to provide secure, survivable strategic communications connectivity, thus allowing B-2 pilots to receive emergency action messages during strategic operations—an EHF capability that U.S. Strategic Command has stated it needs by fiscal year 2016. The third increment is intended to enable the EHF system to connect with the Global Information Grid. The focus of our review was the second increment, which is scheduled to enter the engineering and manufacturing development (EMD) phase in early fiscal year 2013¹ and has an estimated total acquisition cost of \$1.9 billion.

In March 2008, the Air Force started a technology development and concept refinement phase for the second increment of the EHF system.² In summer 2008, Air Force officials raised concerns during systems engineering activities about integration plans for a new EHF antenna subsystem, particularly as they related to the planned antenna location. As a result of these concerns, the Air Force decided to change the location of the antenna for the EHF system, and also changed the type of antenna it planned to use from a mechanically steered array to an active electronically scanned array (AESA).³ Because of concern over the change in antenna, the Senate Armed Services Committee directed us to review the decision process used by the Air Force to make a change in the antenna

¹EMD begins at Milestone B, which is normally formal program initiation for Department of Defense (DOD) weapon system acquisition programs. This phase is intended for completion of the development of a system or increment of capability.

²The technology development and concept refinement phase for Increment 2 includes systems engineering, software preliminary design, technology maturation, antenna prototyping and structural analysis for antenna integration.

³A mechanically steered array has a circular or elliptical antenna plate that requires moving parts to steer a beam across an airspace or ground area; an active electronically scanned array can steer its beams electronically—without moving parts—and redirect them from one location to another.

approach.⁴ This Senate direction was in addition to a request from the House of Representative's Armed Services Committee, Air and Land Forces Subcommittee for us to (1) review the decision-making process used to support the antenna changes, and (2) determine the extent to which the program is employing a knowledge-based acquisition approach to identify and resolve technical gaps prior to the start of EMD. On August 17, 2010, we briefed our findings to congressional staff. The August briefing—with non-substantive revisions made for clarification purposes—is enclosed with this report.

In conducting our review, we obtained data from the Air Force that it used to support its decision to change antennas. We reviewed a 2009 Air Force trade study assessment of antenna subsystem options, B-2 program office antenna risk assessments and cost-benefit analysis data, an Air Force Aeronautical Systems Center (ASC) Structures Branch assessment of B-2 structural risks, contractors' antenna data and aircraft stress analysis, an ASC Acquisition Center of Excellence panel antenna assessment, and other relevant B-2 program management documents. We also interviewed B-2 program officials and ASC Structures Branch officials about the decision-making process, technical assessments, and basis for the decision. Additionally, in preparing our August 2010 briefing we provided a copy to the Air Force for review and their comments were incorporated where appropriate. We performed our review from May 2010 to December 2010 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 based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings based on our audit objectives.

Summary

The Air Force's decision to change the antenna location to lower risks appears reasonable. However, the Air Force's decision process used to change antenna type was not supported by comprehensive, detailed analyses of cost, schedule, and technical risks for alternative antenna options. Without such analyses, it is difficult to determine whether the program is pursuing the most cost-effective and lowest risk antenna solution. An ASC Acquisition Center of Excellence expert panel that examined the antenna selection process found the decision to exclusively pursue an AESA antenna may have precluded lower risk, more mature, and more affordable options. Finally, while the program's acquisition strategy incorporates several knowledge-based practices, there are additional options, particularly the pursuit of more robust competitive prototyping and maturing technologies to higher readiness levels, that could help reduce risk and improve the program's chances of a successful outcome.

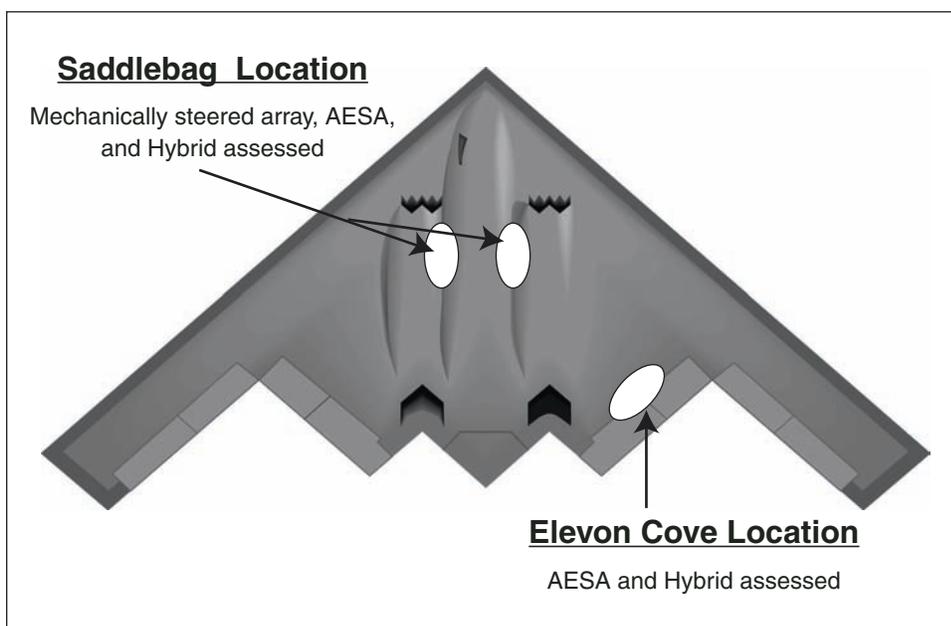
The Air Force's Decision to Change Antenna Locations Appears Reasonable

In 2009, the Air Force completed a trade study that served as the catalyst and primary support for the decision to pursue an alternative antenna location. Because of concerns raised about aircraft modifications that would be required to install the antenna in the

⁴S. Rep. No. 111-201, at 81 (2010).

originally planned antenna location, the B-2 program office examined the feasibility of alternative locations and antennas. Structural analysis supporting the trade study found that installation risk to the aircraft could be substantially lowered by changing the antenna location on B-2 aircraft. The trade study also found that antenna concepts are available that could support a location change. The study focused on two locations for aircraft integration—the originally planned saddlebag (near aircraft center) and the elevon cove (aft part of aircraft)—and three technology options—mechanically steered array, AESA, and hybrid technology that would utilize a combination of the two technologies. Because of size constraints, the mechanically steered array was not considered a viable option for the elevon cove location on the aircraft. The locations and antenna technology options assessed by the trade study are shown in figure 1.

Figure 1: Antenna Options Assessed in Air Force Trade Study



Source: B-2 Program Office.

Note: According to B-2 program officials, two antennas were expected to be needed for the saddlebag location; the elevon cove location requires only one antenna.

Air Force assessments by the ASC Structures Branch and an ASC Acquisition Center of Excellence panel also supported changing the antenna location on the aircraft. The Structures Branch assessment, led by a former B-2 structural engineer, found that integrating an antenna system into the saddlebag location would be more complex and higher risk primarily because of the engineering required and aircraft modification challenges. The ASC Acquisition Center of Excellence panel, comprised of subject matter experts from the Air Force acquisition, manufacturing, and technology development communities, concurred with changing antenna locations from the saddlebag to the elevon cove and noted the rigor of the process used by the program to make this decision.

The Decision Process Used to Change Antenna Type Was Not Supported by Comprehensive Cost, Schedule, and Technical Risks Analyses

The Air Force's decision to pursue an AESA antenna was not supported by a process that provided comprehensive analyses of cost, schedule, and technical risks for alternative antenna options. The Air Force trade study evaluated technical feasibility of different antenna options, but did not assess cost and schedule effects or fully evaluate technical risks.

However, in light of the trade study results, the Air Force requested that the prime contractor reevaluate antenna options and submit its best concept to meet EHF requirements. The Air Force informed the prime contractor that an AESA antenna installed in the elevon cove location was its preferred antenna concept based on trade study findings, but provided the prime contractor with an opportunity to make its own decision on what antenna location and type to pursue. The prime contractor ultimately chose to pursue an AESA antenna for the elevon cove location and submitted a request for information to eight potential suppliers asking for AESA system options. The prime contractor did not request information for any alternative antenna solutions, such as a hybrid antenna. The prime contractor selected one of its other business divisions as the supplier for the AESA antenna subsystem, and the Air Force approved the selection.

Without more comprehensive analyses of cost, schedule, and technical risks for different antenna options, it is difficult to determine whether the program is pursuing the most cost-effective and lowest risk antenna solution. For example, the selected AESA antenna approach relies on development of technologies that are not mature and are thus considered high risk at this point⁵, which makes it difficult to estimate the resources that will be needed to develop and produce the system. While the ASC Acquisition Center of Excellence panel concurred with the prime contractor's decision to change the antenna location and found selection of an AESA antenna defensible, the panel also found that the decision to exclusively pursue an AESA antenna may have precluded use of other lower risk, more affordable antenna options. Specifically, the panel stated that while AESA technology is needed to meet at least part of the antenna subsystem requirements, meeting all EHF requirements with an AESA antenna subsystem will be a significant technical challenge. In particular, the panel noted that several different types of antenna elements or hybrid arrays with lower risk or lower cost, or both, may be available as an alternative to using AESA technology to meet EHF transmit requirements.

Acquisition Approach Employs Several Knowledge-Based Practices, but Additional Options Could Be Considered

Consistent with DOD policy and knowledge-based acquisitions, the Air Force is pursuing several practices that should help position the program for success prior to entering

⁵Because AESA critical technologies for the B-2 EHF system have not yet been demonstrated as a system prototype in a realistic environment, such as in a test-bed aircraft, we consider them high risk based on GAO's best practices work on technology development.

EMD. First, the B-2 EHF system has been broken into three separate increments, each expected to be its own major defense acquisition program. This approach allows for a better matching of requirements and resources, which provides an opportunity to defer challenging requirements until technologies are ready. Second, the B-2 EHF Increment 2 program plans to conduct early systems engineering and design activities, including a preliminary design review, before starting EMD. Finally, the program's preliminary plans indicate efforts to minimize concurrency among development, flight testing, and production.

However, there are additional knowledge-based practices that could be worth considering for the B-2 EHF Increment 2 program. While the Air Force plans to competitively prototype a few selected AESA components that have lower technology maturity levels and higher risk,⁶ a more comprehensive effort that includes competitive prototyping of full antenna subsystems using different technologies and different contractors could reduce risk, validate designs, and lead to better cost estimates, as well as provide a fallback option if the AESA antenna does not mature as planned. A fallback antenna option may be particularly worthwhile given that initial operational capability for the second EHF increment is currently expected about 3-½ years later than U.S. Strategic Command's stated fiscal year 2016 need date, and additional schedule slips would further delay its availability to the warfighter. Also, while the program plans to demonstrate critical technologies in a relevant environment prior to the start of EMD,⁷ demonstrating critical technologies in a realistic environment before EMD could further reduce risks and provide greater assurances that the technologies will work as intended before finalizing the design.⁸ This is especially true given that the B-2 EHF system must meet very stringent nuclear-hardening requirements and any later design changes could require significant additional time and money.

Agency Comments

The Office of the Secretary of Defense was presented with a copy of a draft version of this report and given an opportunity to provide comments. However, the Office of the Secretary of Defense did not provide comments on the draft report to GAO. For the

⁶DOD Directive-Type Memorandum (DTM) 09-027, Implementation of the Weapon Systems Acquisition Reform Act of 2009 (WSARA) (Dec. 4, 2009), implements WSARA, including competitive prototyping requirements. WSARA requires that DOD policy ensure acquisition strategies for major defense acquisition programs provide for competitive prototypes before Milestone B approval unless a waiver is properly granted. Pub. L. No. 111-23 § 203.

⁷The National Defense Authorization Act for Fiscal Year 2006 included a provision requiring all major defense acquisition programs seeking Milestone B approval—entry into EMD—to obtain certification that program technologies have been demonstrated in a relevant environment, which is technology readiness level (TRL) 6. Pub. L. No. 109-163 § 801, codified at 10 U.S.C. § 2366b. TRL 6 is achieved by testing a representative model or prototype system that is very close to form, fit, and function in a relevant environment, like in a high-fidelity lab or simulated operational environment.

⁸GAO best practice work supports technology demonstration in a realistic environment—TRL 7—before the start of EMD. TRL 7 represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in a test-bed aircraft.

August 2010 briefing that is enclosed with this report, the Air Force was provided a copy for review and their comments were incorporated where appropriate.

We are sending copies of this report to interested congressional committees, the Secretary of Defense, and the Secretary of the Air Force. In addition, this report will be available at no charge on GAO's Web site at <http://www.gao.gov>.

Should you or your staff have any questions on the matters covered in this report, please contact me at (202) 512-4841 or sullivanm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Other major contributors to this letter were Marie P. Ahearn, Bruce Fairbairn, Matt Lea, and Sean Merrill.

A handwritten signature in black ink, appearing to read 'Michael J. Sullivan', with a stylized flourish at the end.

Michael J. Sullivan, Director
Acquisition and Sourcing Management
Enclosure

List of Committees

The Honorable Carl Levin
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The Honorable John McCain
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Daniel Inouye
Chairman
The Honorable Thad Cochran
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Ike Skelton
Chairman
The Honorable Howard P. McKeon
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Norman D. Dicks
Chairman
The Honorable C.W. Bill Young
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives



**B-2 Extremely High Frequency (EHF)
Satellite Communications (SATCOM)
Increment 2 Program Acquisition Approach**

**Briefing for the Committees on Armed Services
U.S. Senate and House of Representatives**

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GAO Objectives and Scope

- The House Armed Services Committee asked us to review the decision-making process used by the B-2 program office to change antenna subsystem solutions, and determine the extent to which the program is employing a knowledge-based acquisition approach and systems engineering practices to identify and resolve technical gaps prior to the start of system development. Subsequent Senate direction¹ asked us to review the decision-making process used by the Air Force to select a new antenna solution.
- We interviewed B-2 program and other Air Force officials and reviewed a 2009 trade study assessment of antenna subsystem options, program office risk assessment and cost-benefit analysis data, contractors' aircraft stress analysis and make-buy decision materials, and other related programmatic documents.

¹S. Rep. No. 111-201, at 81 (2010).

Summary of Findings

- The decision to change antenna locations appears reasonable from an integration standpoint, but concerns remain over technology risk and the strategy for acquiring the active electronically scanned array (AESA) antenna.
- A 2009 Air Force trade study found the B-2 EHF Increment 2 program's key performance parameters (KPP) were not achievable and there was substantial risk with integrating an antenna subsystem in the saddlebag region.
- The subsequent decision to change antenna location to the elevon cove effectively eliminated the mechanically steered array (MSA) antenna option due to its size.
- An Air Force panel agreed with antenna location change, but said there may be lower risk/more affordable technologies options than the AESA technologies being pursued.
- Although technical characteristics were assessed and a new antenna location in the elevon cove was selected, the program office did not analyze cost and schedule factors to support selection of AESA over MSA and hybrid options.
- AESA antenna critical technologies are assessed at low readiness levels (TRLs 3-4) and thus high risk; the program's development approach does not provide a fallback antenna technology option should the AESA technology not mature as expected.
- The program's acquisition strategy incorporates several knowledge-based practices, but we identified additional opportunities to reduce future risks, such as pursuing more comprehensive competitive prototyping.

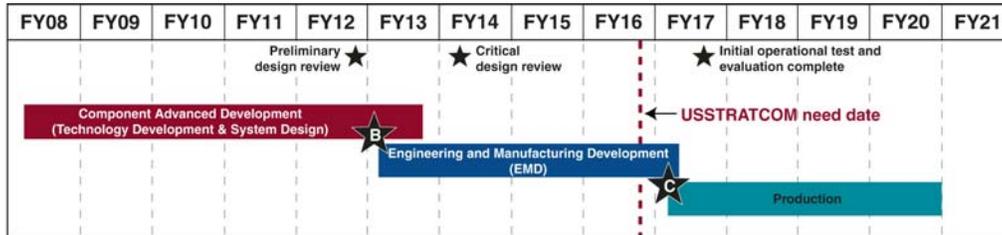
B-2 EHF Program Description

- The B-2 EHF system is expected to provide secure, survivable communications and will replace the existing ultra high frequency system that uses aging MILSTAR satellites. The new system will use an Advanced EHF satellite system with first satellite launch expected in 2010.
 - The Air Force is developing and procuring the B-2 EHF system in three separate increments, each expected to be its own major defense acquisition program:
 - Increment 1 upgrades computer system speed and storage capacity, provides new integrated processing units and disk drives, and enables a growth path for future B-2 upgrades.
 - Increment 2 provides secure, survivable strategic communications connectivity by adding low observable antennas and radomes, and includes the family of advanced beyond line-of-sight terminals (FAB-T) and related hardware.
 - Increment 3 improves tactical/conventional communications that migrates to current/future EHF communication architecture and enables net-ready capability for improved situational awareness.
 - Our review was limited to the B-2 EHF Increment 2 program.
-

B-2 EHF Increment 2 Top-Level Schedule and Cost

- B-2 EHF’s three-increment approach was established in January 2006, with Increment 2 beginning pre–Milestone B activities in March 2008. Ongoing component advanced development work includes systems engineering, software preliminary design, technology maturation, antenna prototyping, and structural analysis for antenna integration prior to Milestone B program start, which is now expected in fiscal year 2013.
- Increment 2, which is expected to be the most expensive of the three EHF increments (\$1.9 billion), is largely an antenna development and FAB-T integration effort.

Figure 1: 2010 Program Schedule



Source: B-2 Program Office.

Note: Data are from April 2010 brief to Secretary of the Air Force (Acquisition), and June 2009 Program Management Review brief.
USSTRATCOM = United States Strategic Command.

B-2 EHF Increment 2 Status

- Milestone B has been delayed over 3 years from the original acquisition strategy schedule.
 - Development delays in the FAB-T program, key to Increment 2, have significantly affected the EHF schedule.
 - Acquisition strategy changes (i.e., moving preliminary design review (PDR) before Milestone B) also resulted in schedule revisions.
- Changing the antenna subsystem approach and location has further affected the program schedule and acquisition strategy.
- Under the current schedule, the program will not begin production by the current U.S. Strategic Command need date in fiscal year 2016. Accelerating the schedule in an effort to meet the need date would likely involve accepting more risk.

Program Office Raised Concerns with Requirements and Antenna Subsystem

- In 2005, the Air Force directed the prime contractor to conduct an antenna trade study. The study found an MSA antenna subsystem installed in the B-2's saddlebag area was the preferred approach for Increment 2. While installation risk was reviewed in the trade study, an in-depth analysis of structural integration risk was not completed.
- During summer 2008, B-2 program officials began raising concerns about the planned antenna subsystem location, and these concerns were considered at the System Requirements Review in December 2008.
- In February 2009, the Assistant Secretary for the Air Force (Acquisition)—responding to requirements issues and the inability of the program to meet U.S. Strategic Command's need date—directed a trade study be performed to investigate alternative technical and material solutions for B-2 EHF SATCOM development and integration as well as opportunities to support future growth capability.

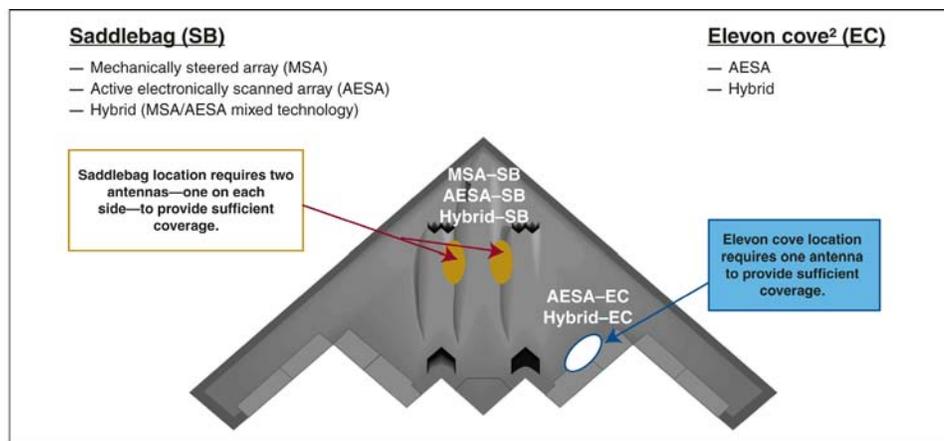
2009 Air Force Trade Study Focused on Technical Viability

- The 2009 trade study was limited to a review of the technical viability of program requirements (KPP objectives) and antenna subsystem options.
- KPPs were evaluated to determine whether objectives as defined in the capabilities development document (identifies the system's expected capabilities) could be accomplished with available technologies.
- Study assessed technical feasibility and structural risk of two installation locations—the saddlebag and elevon cove—and three technology options (MSA, AESA, and a hybrid combination of both).
- According to program officials, the antenna study was not intended to, nor did it prioritize key subsystem characteristics or assess cost and schedule factors for each option.

Trade Study Assessed Antenna Options

The 2009 study focused on two locations, with different technology options assessed at each location as appropriate.

Figure 2: Trade Study Antenna Options



Source: B-2 Program Office.

²MSA antenna technology was not assessed in the eleon cove location because it was determined by the program office to be too large for the location. Page 10

What the 2009 Trade Study Found

- The trade study determined that requirements needed revision because no antenna subsystem concept could meet all four KPPs as drafted in the capabilities development document.
- Its assessment of B-2 EHF antenna locations and technologies determined:
 - All antenna location and technology options assessed were viable but carry different risks and technology maturity timelines.
 - Antenna location for integration much more of a determinant than expected. Elevon cove location reduced integration risk compared to the saddlebag.
 - Radar cross section did not dictate a specific antenna location or technology change, but a move to the elevon cove could reduce the effect on aircraft low observable qualities. Low-probability of intercept/detection options of AESA matched or exceeded MSA results.
- Although the study assessed all options as viable, from the program's perspective it provided evidence that an alternate location and technology exists that has lower integration risk than the MSA in the saddlebag option.

Actions Taken since the 2009 Trade Study

- KPPs were revised to reflect achievable objectives based on what is technically feasible.
- Program office requested the prime contractor reevaluate antenna solution options and submit its best concept to meet Increment 2 requirements. Specific antenna location or technology were not prescribed, but the contractor was aware that an AESA antenna in the elevon cove was the preferred system concept based on trade study findings.
- The prime contractor chose to pursue an AESA antenna subsystem in the elevon cove and submitted a request for information to eight subcontractors asking for potential AESA system options as part of its “make-buy” decision. The prime contractor selected one of its sister divisions to develop the AESA antenna subsystem.

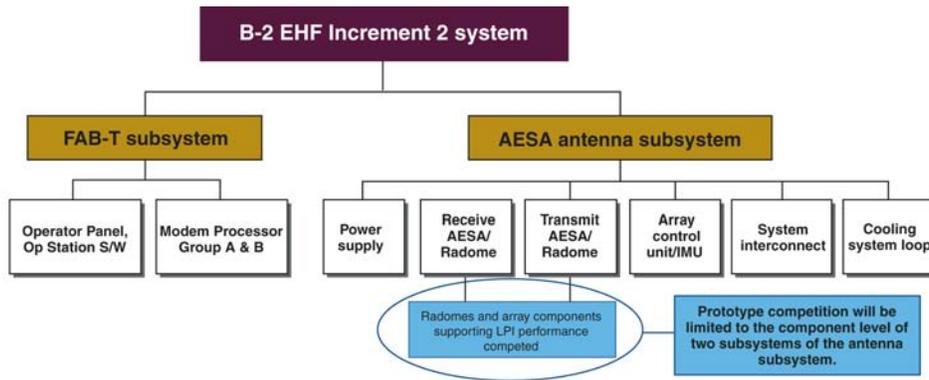
Actions Taken since the 2009 Trade Study (continued)

- In December 2009, an Air Force panel of Aeronautical Systems Center (ASC) engineers assessed and concurred with the prime contractor's make-buy decision for an AESA antenna in the elevon cove location. The panel agreed that AESA technology was needed to provide downlink capability, but found insufficient data to support the need for an AESA-specific uplink capability.
- Program office completed a cost-benefit analysis in February 2010, concluding that estimated cost for competitively prototyping two full AESA antenna subsystems exceeded potential estimated benefits.
- Air Force decided to competitively prototype key AESA subcomponents that had low TRLs and higher risk.³

³DOD Directive-Type Memorandum (DTM) 09-027, Implementation of the Weapon Systems Acquisition Reform Act of 2009 (WSARA) (Dec. 4, 2009), implements WSARA, including competitive prototyping requirements. WSARA requires that DOD policy ensure acquisition strategies for major defense acquisition programs provide for competitive prototypes before Milestone B approval unless a waiver is properly granted. Pub. L. No. 111-23 § 203.

EHF Increment 2 System Planned Competitive Prototyping Approach

Figure 3: B-2 EHF Increment 2 Planned Competitive Prototyping



Source: GAO analysis of data.

- Program’s stated competitive prototyping strategy is to compete AESA components that contribute to optimal radio frequency, radar cross section, and low probability of intercept (LPI) design performance and risk reduction.

Note: Data are from December 2009 B-2 EHF Increment 2 brief and May 2010 B-2 EHF SATCOM Increment 2 Competitive Prototyping Acquisition Strategy Update. Op = operator; S/W = software; IMU = inertial measurement unit.

GAO Observations about Decision Process Leading to Antenna Subsystem Change

- Program office has attempted to make decisions that balance requirements with technology solutions prior to Milestone B, consistent with DOD acquisition policy and GAO best practices.
- Trade study technical assessment was the catalyst and primary support for the program's decision to pursue an alternate antenna location. The location change decision appears reasonable from a technical standpoint based on trade study results and other supporting internal Air Force assessments.
- Change to the elevon cove location may lower antenna integration risk, but it does not necessarily reduce technology risk. AESA technologies have low technology readiness levels (primarily TRL 3-4 based on program office self-assessment).
- Characteristics of the different antenna options assessed were not prioritized, and life-cycle cost and schedule analyses for the different antenna options were not completed to support selection of the antenna technology approach.

GAO Observations about Decision Process (continued)

- Air Force ASC panel found the decision to exclusively pursue AESA solutions may have precluded use of lower risk, more affordable technologies, particularly as they relate to several different transmit uplink antenna elements or hybrid arrays that may be viable options.
- Given the stated time-critical nature (2016 need date) for the availability of this EHF capability, a technology development approach that pursues more than one antenna technology solution (e.g. AESA and hybrid) could provide flexibility if one of the antenna technologies cannot be matured as expected.
- Competitive prototyping of different antenna technologies by different contractors has the potential to increase contractor performance and could provide a fallback technology option.

Some Knowledge-Based Acquisition Practices Being Used, but Additional Opportunities Remain

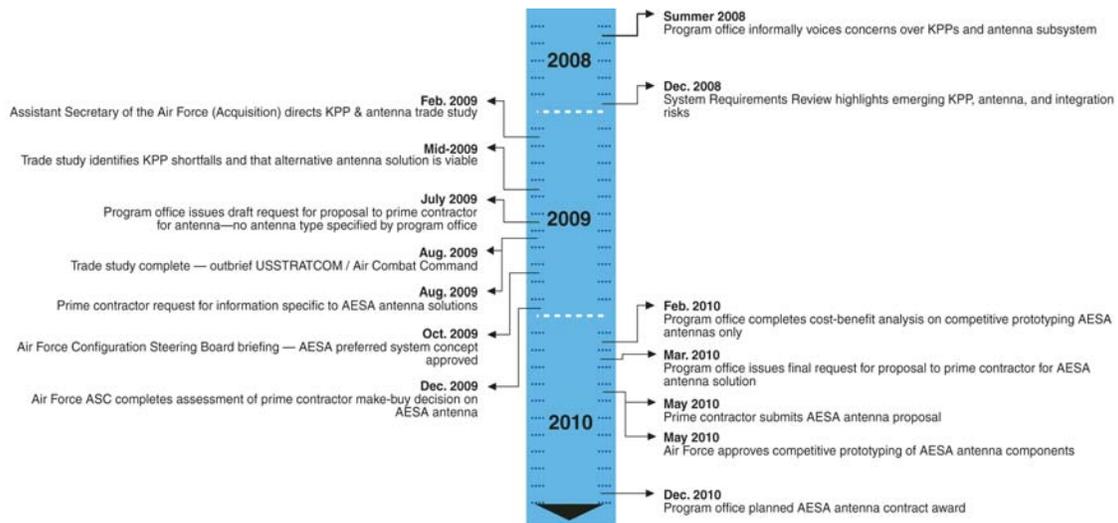
- The B-2 EHF Increment 2 program’s overall acquisition strategy includes several sound knowledge-based practices:
 - Developing system in three defined increments, each its own program.
 - Early systems engineering and design efforts, including a PDR before EMD.
 - Minimized concurrency among development, flight testing, and production.
- Additional opportunities to further reduce overall risk of future problems include:
 - Completing Milestone A review to support a sound business case.
 - Demonstrating technologies to TRL 7 before Milestone B.⁴
 - Ensuring that PDR includes fully functional and capable FAB-T.
 - Pursuing additional competitive prototyping opportunities.

⁴The National Defense Authorization Act for Fiscal Year 2006 included a provision requiring all major defense acquisition programs seeking Milestone B approval—entry into EMD—to obtain certification that program technologies have been demonstrated in a relevant environment, which is TRL 6. Pub. L. No. 109-163 § 801, codified at 10 U.S.C. § 2366b. GAO best practices support technology demonstration in a realistic environment—TRL 7—before EMD. Page 17

Additional Materials

Timeline of Key B-2 EHF Increment 2 Events

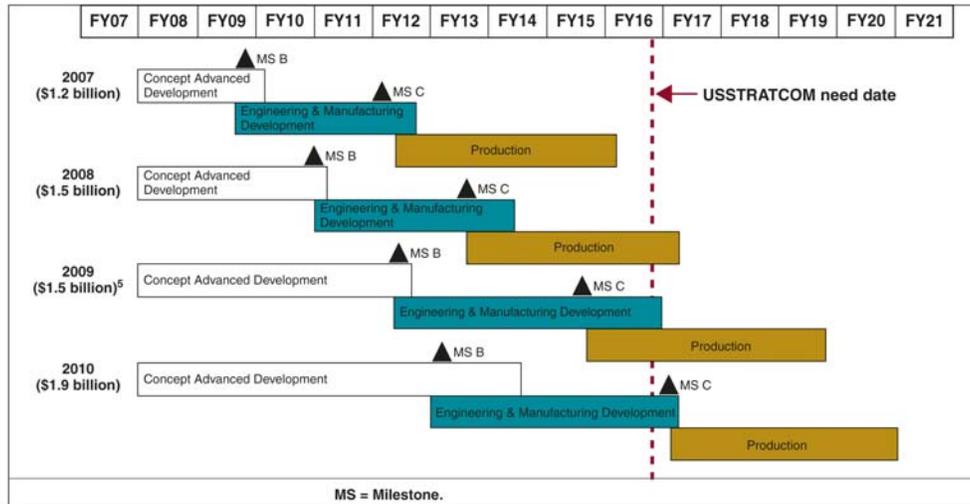
Figure 4: B-2 EHF Increment 2 Timeline



Source: GAO analysis of B-2 Program Office data.

Evolving Acquisition Plans and Costs

Figure 5: B-2 EHF Increment 2 Schedule and Total Cost Estimates over Time

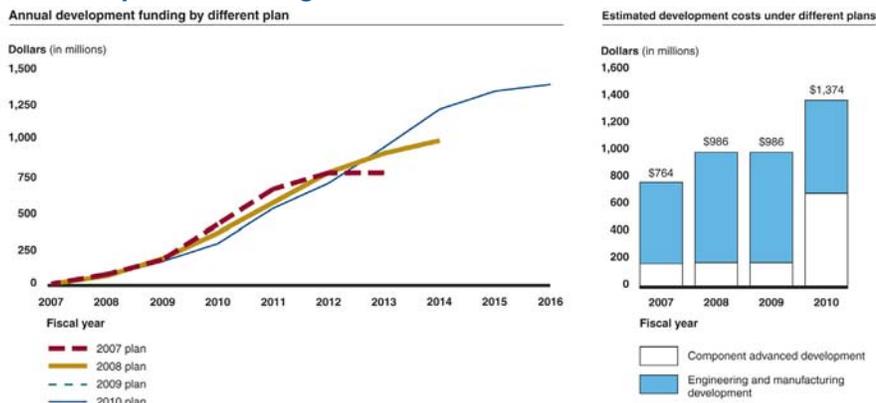


Source: GAO analysis of B-2 Program Office data.

⁵The B-2 EHF Increment 2 program cost estimate was not revised by the program office to reflect changes that occurred in fiscal year (FY) 2009 until FY2010.

B-2 EHF Increment 2 Development Cost Estimate Evolution

Figure 6: Development Funding and Estimated Costs for Different Plans⁶



Source: GAO analysis of B-2 Program Office data.

- Total estimated development cost has increased \$610 million since 2007. Delay to FAB-T delivery and increased understanding of the complexity and cost of integration contributed to the cost increase and additional development time reflected in the 2010 plan.
- Additional resources were required before Milestone B to resolve requirements and technology gaps that were identified during systems engineering activities.
- About half of the program's development cost is now expected for pre-Milestone B activities.

⁶The B-2 EHF Increment 2 program cost estimate was not revised by the program office to reflect changes that occurred in FY2009 until FY2010.

Attributes of the Program Office’s Assessment of Antenna Subsystem Options

Table 1: Attributes of Antenna Options Assessed

Attributes	Attribute consideration in decision process?	Description of process and activities
Technical characteristics	Yes	For each antenna location/technology option, the 2009 trade study evaluated capacity, coverage, radar signature, power management, integration risk, and probability of detection/intercept. A structural analysis was completed by ASC Structures Branch on integration risks for the saddlebag and elevon cove locations.
Cost	No	We found no evidence of a cost-benefit analysis for each different antenna technology solution option from the 2009 trade study. According to program officials, the only related cost analysis performed was the February 2010 cost-benefit analysis of competitively prototyping two AESA antenna subsystems. This analysis was performed after the decision to change antennas.
Schedule	Limited	Program office self-assessed achievability of TRL 6 for antenna technology by Milestone B to identify risk of each option based on the expected schedule. Program officials stated no full schedule assessment was completed for the different antenna technology options and their ability to meet the USSTRATCOM need date.

Source: GAO analysis of B-2 Program Office data.

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