United States Government Accountability Office

Report to Congressional Committees

March 2017

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

GAO-17-333SP

GAO Highlights

Highlights of GAO-17-333SP, a report to congressional committees

March 2017

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

Why GAO Did This Study

This is GAO's annual assessment of DOD's major weapon system acquisitions, an area on GAO's high-risk list. DOD and Congress have taken steps to improve the acquisition of weapon systems. Still some programs continue to experience cost and schedule overruns. GAO continues to emphasize the need for DOD and Congress to hold programs accountable by ensuring that they attain the required knowledge at key decision points before committing resources to development. Given continuing budgetary pressures, DOD cannot afford to miss opportunities to address program inefficiencies.

The joint explanatory statement to the DOD Appropriations Act, 2009 includes a provision for GAO to annually review DOD's portfolio of weapon systems. This report includes observations on (1) the cost and schedule performance of DOD's 2016 portfolio of 78 major defense acquisition programs, (2) program implementation of key acquisition reform initiatives, and (3) the knowledge attained at key decision points for 54 weapon programs in development or early production.

GAO analyzed cost, schedule, and quantity data from DOD's Selected Acquisition Reports from 2010, 2014, and 2015. GAO also collected program office data through two questionnaires on technology, design, and manufacturing knowledge; the use of knowledge-based acquisition practices; and the implementation of acquisition reforms and initiatives.

In commenting on a draft of this report, DOD agreed with GAO's findings and stated that the results validate its focus on continuous program improvements.

View GAO-17-333SP. For more information, contact Michael J. Sullivan at (202) 512-4841 or sullivanm@gao.gov

What GAO Found

Since GAO's 2016 assessment, the number of programs in the Department of Defense's (DOD) portfolio of major defense acquisitions decreased from 79 to 78, while DOD's planned investment over the life of these programs increased by $9.4 billion to $1.46 trillion. GAO observed mixed performance in the portfolio this year. For example, although the current portfolio has incurred $484 billion in total cost growth, $476 billion of this occurred 5 or more years ago, indicating recent performance has improved. Yet, 60 percent of the total cost growth occurred after programs entered production, when costs should be more stable. However, the portfolio increased its buying power by $10.7 billion—meaning DOD is able to buy more goods or services for the same level of funding. This gain resulted from some programs finding procurement efficiencies that more than offset inefficiencies in other programs. The 19 newest programs decreased their costs by a combined $3.4 billion over the past year.

Implementation of key reform initiatives GAO analyzed for the 45 current and 9 future programs it assessed this year was similar or slightly less as compared to its 2016 assessment. These initiatives address program and portfolio affordability, cost growth controls, and competition use. For example, 42 programs this year reported conducting "should-cost" analyses, which are designed to reduce programs' costs by identifying and eliminating inefficiencies. Programs can take a variety of actions, such as reducing overhead, to do so. Programs implementing "should-cost" analyses reported realizing $23.6 billion in savings, although they could not identify to GAO exactly where $11.0 billion of these savings were transferred within DOD. Also, a similar number of programs reported establishing affordability constraints, which programs use to set priorities and inform what they can and cannot afford. GAO found that current programs with established affordability constraints had a lower average amount of cost growth from initial estimates compared to programs without a constraint. However, DOD's implementation of another key reform initiative—the fostering of competitive environments in acquisition—is stagnant. Compared to GAO's 2016 assessment, more programs this year reported having no plans for competition before or after development start. Lastly, 31 current programs reported that they are scheduled to complete the evaluation of their potential cyber vulnerabilities by 2019, required by the 2016 fiscal year National Defense Authorization Act.

Most of the programs GAO assessed this year are not yet fully following a knowledge-based acquisition approach, as GAO has previously recommended. This held true for the four programs that recently entered system development as only one completed all of the applicable GAO criteria for a best practices approach. Three of the four implemented some knowledge-based practices, such as completing a system-level preliminary design review before development start. Meanwhile, other practices, such as fully maturing technologies prior to system development start and completing systems engineering reviews, were not fully implemented. As a result, these programs will carry unwanted risk into subsequent phases of acquisition that could result in cost growth or schedule delays. In addition, a number of programs are concurrently conducting software and hardware development during production, further exposing programs to undue cost and schedule risk.

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Abbreviations

AMPV	Armored Multi-Purpose Vehicle
B-2 DMS-M	B-2 Defensive Management System Modernization
BMDS	Ballistic Missile Defense System
Columbia Class SSBN	Columbia Class Ballistic Missile Submarine
CIRCM	Common Infrared Countermeasure
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
EELV	Evolved Expendable Launch Vehicle
eSRS	Electronic Subcontracting Reporting System
F-15 EPAWSS	F-15 Eagle Passive/Active Warning and Survivability System
F-22 Inc 3.2B	F-22 Increment 3.2B Modernization
IFPC Inc 2-I Block 1	Indirect Fire Protection Capability Increment 2–Intercept Block 1
JLTV	Joint Light Tactical Vehicle
KC-46A	KC-46A Tanker Modernization
LCS	Littoral Combat Ship
MDAP	Major Defense Acquisition Program
MRL	manufacturing readiness level
NA	not applicable
OASuW Inc 1	Offensive Anti-Surface Warfare Increment 1
PAC-3 MSE	Patriot Advanced Capability-3 Missile Segment Enhancement
PAR	Presidential Aircraft Recapitalization
SAR	Selected Acquisition Report
TBD	to be determined
TRL	technology readiness level
VH-92A	VH-92A Presidential Helicopter Replacement
WSARA	Weapon Systems Acquisition Reform Act

GAO U.S. GOVERNMENT ACCOUNTABILITY OFFICE

441 G St. N.W.
Washington, DC 20548

Comptroller General
of the United States

March 30, 2017

Congressional Committees

I am pleased to present GAO's 15th annual assessment of the Department of Defense's (DOD) major defense acquisition programs. This report offers observations on the performance of DOD's current $1.46 trillion portfolio of 78 programs.[1] These 78 programs will require just over one quarter of all DOD's development and procurement funding over the next 5 years. This significant financial investment demands keen oversight and continued implementation of key legislative and policy reforms as well as knowledge-based best practices developed by GAO.[2] Over the past several years, we have found that many DOD programs have not uniformly implemented these reforms or best practices.

Our current assessment shows that the progress DOD has made since 2010 to decrease the amount of cost growth in its portfolio has now flattened out. When compared to last year's portfolio, the 2016 portfolio includes one fewer program but is estimated to cost nearly $9.4 billion more, as a majority of programs experienced cost increases over the past year. We also found that programs in the 2016 portfolio incurred an average delay in delivering capability of almost 2 months. More encouraging, we found that programs that started development after the implementation of the Weapon Systems Acquisition Reform Act of 2009 (WSARA) and DOD's "Better Buying Power" initiatives began in 2010 saw cost decreases over the past 2 years, indicating that recent reforms may be having a positive effect, though the decrease was not significant enough to avert an overall cost increase in the portfolio.

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[1] Our assessment of DOD's portfolio does not include the cost of the Ballistic Missile Defense System (BMDS), as the program and its elements lack acquisition program baselines needed to support our assessment of cost and schedule change. For more information, on BMDS and its elements see GAO, *Missile Defense: Ballistic Missile Defense System Testing Delays Affect Delivery of Capabilities,* GAO-16-339R (Washington, D.C.: Apr. 28, 2016). 10 U.S.C. § 225 requires MDA to establish and maintain an acquisition baseline for certain elements of the BMDS, but these baselines are not the same as the acquisition program baselines developed pursuant to 10 U.S.C. § 2435 and DOD acquisition policies. For example, they do not include service-funded operations and sustainment costs needed to support GAO's assessment of cost and schedule change.

[2] See, e.g., Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23.

Nonetheless, we found that new programs continue to implement only some of the knowledge-based best practices that are necessary at program start to provide sufficient knowledge as to whether a program is capable of meeting its performance requirements while also meeting its cost and schedule commitments. It is at program start that decision makers have the most leverage to ensure that the program exhibits desirable principles—namely, a match between its resources and requirements—before funding and approving the program. A program's technology maturity provides a key indicator of whether this match has been achieved. Our analysis also highlights other key points in the acquisition cycle where knowledge-based best practices should be better applied. For example, programs often hold major design reviews and enter production prior to demonstrating the product's design is stable and can be manufactured within cost, schedule, and quality targets. In addition, we also observed that nearly half the programs in the current portfolio fielded or planned to field initial capabilities prior to fully demonstrating those capabilities through operational test and evaluation. Programs doing this risk fielding systems that are later found to be ineffective or unsuitable for missions.

Weapon system acquisitions remain an area on GAO's high-risk list.[3] Continued efforts by DOD to mitigate these risks through adherence to best practices and effective program management are essential.

Gene L. Dodaro

Gene L. Dodaro
Comptroller General
of the United States

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[3] GAO, *High-Risk Series: Progress on Many High-Risk Areas, While Substantial Efforts Needed on Others*, GAO-17-317 (Washington, D.C.: Feb. 15, 2017).

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Washington, DC 20548

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In response to the joint explanatory statement accompanying the Department of Defense Appropriations Act, 2009, this report provides insight into the department's $1.46 trillion portfolio of major weapon programs.[1] This report also includes information related to small business participation pursuant to a mandate in a report for the National Defense Authorization Act for Fiscal Year 2013.[2] Additionally, this report's assessment of the Navy's Presidential Helicopter Program constitutes GAO's response to the annual reporting requirement for 2017 required by the National Defense Authorization Act for Fiscal Year 2014.[3]

This report includes observations on (1) the cost and schedule performance of DOD's 2016 portfolio of 78 major defense acquisition programs, (2) program implementation of key acquisition reform initiatives, and (3) the knowledge attained at key decision points in the acquisition process for 54 current and planned weapon programs.[4]

Our observations in this report are based on three sets of programs:

- We assessed 78 major defense acquisition programs in DOD's 2016 portfolio for our analysis of cost and schedule performance. We obtained cost, schedule, and quantity data from DOD's December

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[1] See Explanatory Statement, 154 Cong. Rec. H 9427, 9526 (daily ed., Sept. 24, 2008), to the Department of Defense Appropriations Act, 2009, contained in Division C of the Consolidated Security, Disaster Assistance, and Continuing Appropriations Act, 2009, Pub. L. No. 110-329 (2008).

[2] H.R. Rep. No. 112-479, at 284 (2012). The National Defense Authorization Act for Fiscal Year 2013, Pub. L. No.112-239.

[3] The National Defense Authorization Act for Fiscal Year 2014, Pub. L. No.113-66, § 252 (2013).

[4] Major defense acquisition programs (MDAP) are those identified by DOD or with a dollar value for all increments estimated to require eventual total expenditure for research, development, test, and evaluation of more than $480 million, or for procurement of more than $2.79 billion, in fiscal year 2014 constant dollars. DOD has a list of programs designated as future major defense acquisition programs. These programs have not formally been designated as MDAPs; however, DOD plans for these programs to enter system development, or bypass development and begin production, at which point they will likely be designated as MDAPs. We refer to these programs as future or planned major defense acquisition programs throughout this report.

2015 Selected Acquisition Reports (SAR), which detail initial cost, schedule, and performance baselines as well as changes to baselines over the past year, and from the Defense Acquisition Management Information Retrieval Purview system, a DOD repository for program data. We assessed the reliability of the data by analyzing it and reviewing the steps officials take to ensure the system's data reliability, and determined that the data were sufficiently reliable for the purposes of our report.

- We assessed 45 major defense acquisition programs currently between the start of development and the early stages of production for knowledge attained at key decision points and their implementation of acquisition reforms. We obtained information on the extent to which the programs follow knowledge-based practices—identified by our past work included in the Related GAO Products section of this report—for technology maturity, design stability, and production maturity using two data-collection instruments. One was a questionnaire on issues such as systems engineering, design drawings, manufacturing planning and execution, and the implementation of specific acquisition reforms. The other was a data-collection instrument for determining schedule dates, critical technology levels, and other information. We received questionnaire responses from all 45 current programs from August through October 2016.
- We also assessed 9 future major defense acquisition programs not yet in the portfolio in order to gain additional insights into knowledge attained before the start of development and plans for implementation of key acquisition reform initiatives. We submitted a questionnaire to program offices to collect information on issues such as program schedule events, costs, and numerous acquisition reforms, and received responses from all 9 future programs from August through October 2016.

We present individual assessments of 54 programs—45 current and 9 future weapon programs.[5] These assessments include major defense acquisition programs currently in development or early production as well

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[5] In addition to the 54 program assessments, we separately assessed the Navy's Frigate initiative, which is currently part of the Navy's Littoral Combat Ship program. We assessed the P-8A Poseidon Multi-Mission Maritime Aircraft Increment 3 as part of the 9 future major defense acquisition programs not yet in the portfolio. During the course of our review, we learned that DOD no longer plans to manage Increment 3 separately from the existing P-8A program. We will reflect this change in future assessments of the P-8A program.

as future programs. Appendix I contains detailed information on our scope and methodology.

We conducted this performance audit from April 2016 to March 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

DOD acquires new weapons for its warfighters through a management process known as the Defense Acquisition System.[6] This system generally requires defense acquisition programs to proceed through phases of development, which include a series of milestone reviews and other key decision points that may authorize entry into a new phase of acquisition. Once a decision has been made regarding the concept of the product to be acquired, the program may enter the initial phase of technology development, known as Technology Maturation and Risk Reduction. The purpose of this phase is to reduce technology, engineering, integration, and life-cycle cost risk to the point that a decision to contract for system development can be made with confidence in successful program execution for development, production, and sustainment. After that, the engineering and manufacturing development phase is to develop, build, and test a product to verify that all operational and derived requirements have been met, and to support production or deployment decisions. In this report, we refer to DOD’s engineering and manufacturing development phase as system development. The final phase, before sustainment, is production and deployment, the purpose of which is to produce and deliver requirements-compliant products to receiving military organizations. In the production phase, the product is produced and fielded for use by operational units. Low-rate initial production, limited deployment, operational test and evaluation, and full rate production all occur in this phase. These various phases allow DOD to oversee and manage programs’ development

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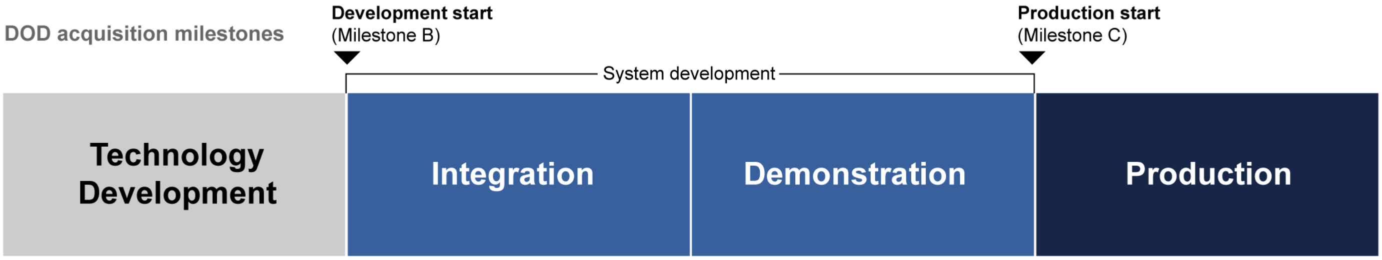
[6] Department of Defense Directive 5000.01, *The Defense Acquisition System* (Nov. 2007); Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* (Jan. 2015) (“DOD Instruction 5000.02”). An update to this instruction was released in January 2017, after we completed much of our analyses.

strategies and activities. Figure 1 illustrates the key milestones and reviews associated with the Defense Acquisition System.

Figure 1: Defense Acquisition System



Source: GAO analysis of Department of Defense (DOD) Instruction 5000.02. | GAO-17-333SP

Each year, DOD releases Selected Acquisition Reports (SAR) on the status of its major defense acquisition programs, including a comprehensive annual SAR that is generally submitted in conjunction with the submission of the President's Budget.[7] The cost estimates provided in the SARs include four types of funding: research and development, procurement, military construction, and acquisition-related operations and maintenance. These costs reflect actual costs to date as well as future anticipated costs. We use the SAR data to analyze and report on the progress of all of the current major defense acquisition programs, which we refer to as the current DOD portfolio. The DOD Instruction 5000.02 is implementing policy that describes the steps and procedures that programs generally follow as they proceed through the defense acquisition system. Since 2013, this instruction has incorporated certain 2010 acquisition reform initiatives.

DOD and Congress have previously addressed some of the challenges and problems in the defense acquisition system. Over the years, these entities have explored ways to improve acquisition outcomes. Most notably, the Weapon Systems Acquisition Reform Act of 2009 (WSARA) aimed to improve the organization and procedures of DOD for the acquisition of major weapon systems.[8] Among other things, WSARA revised the certifications that programs were expected to complete before

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[7] SAR reporting is statutorily required. 10 U.S.C. § 2432.

[8] Pub. L. No. 111-23.

being approved for system development start.[9] Programs are currently required to make certain determinations and certifications that they have met the following requirements, among others, prior to entering system development:

- Appropriate trade-offs among cost, schedule, and performance objectives have been made to ensure the program is affordable;
- A preliminary design review and formal post-preliminary design review assessment have been conducted and, on the basis of such assessment, the program demonstrates a high likelihood of accomplishing its intended mission; and
- Technology has been demonstrated in a relevant environment on the basis of an independent review and assessment by the Assistant Secretary of Defense for Research and Engineering.

Since WSARA was implemented in late 2009, some of its requirements have been revised or repealed. The National Defense Authorization Act for Fiscal Year 2016 repealed the requirement for programs to conduct competitive prototyping prior to starting system development.[10] Now, acquisition strategies are to include competitive prototyping before starting system development, to the maximum extent practicable and consistent with the economical use of available financial resources, rather than required.

In 2010, DOD started its own acquisition reform initiatives in its “Better Buying Power” memoranda. These reforms include requiring programs to conduct affordability and “should-cost” analyses, among other things, which can result in placing cost constraints on programs and encouraging programs to find cost improvements during program execution. In addition, one of the initiatives in DOD’s “Better Buying Power” memos is aimed at implementing practices and policies designed to improve the productivity of DOD and its industrial base. Many of the WSARA requirements and DOD initiatives have been incorporated into the DOD Instruction 5000.02. These and other reforms address sound management practices, such as realistic cost estimating, prototyping, and systems engineering. However, we previously found that the results of these reforms and initiatives might be limited if programs do not follow the

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[9] This requirement is codified as amended at 10 U.S.C. § 2366b.

[10] Pub. L. No. 114-92, § 822(b).

knowledge-based best practices GAO has identified for product development.[11]

Observations on the Cost and Schedule Performance of DOD's 2016 Major Defense Acquisition Program Portfolio

Since our last report in 2016, our analysis shows that DOD's total planned investment in major defense acquisition programs increased by about $9.4 billion from $1.45 trillion to $1.46 trillion, whereas the number of programs decreased from 79 to 78. The cost increase represents a flattening to a trend of total acquisition cost decreases we observed each year from 2010 to 2015. We attribute this aggregate cost increase to cost growth affecting a majority of individual DOD programs over the past year, and, in particular, significant cost increases in a few large shipbuilding programs.

Our analysis also shows that the portfolio has experienced cost growth totaling over $484 billion since programs established their first full estimates; 60 percent of the cost growth occurred after programs started production. These significant post-production cost increases—particularly within development funds—may indicate that programs start production without having demonstrated that a fully integrated, capable, production-representative prototype will work as intended. Notably, $476 billion of this cost growth occurred in programs 5 or more years ago. Since 2011, the portfolio's cost has only grown by $8.6 billion. Based on our review of DOD estimates, the amount of future funding needed to complete the 2016 portfolio totals $573.6 billion, which is a decrease from the 2015 portfolio and is the lowest amount in over a decade. The decreased amount of future funding required indicates that more of the total cost of the portfolio has been spent.[12] Of the $573.6 billion, $546 billion is planned for procurement and $27.6 billion, or 5 percent of the total, is planned for development. Over the past 2 years, the portfolio has experienced a buying power gain. Further, the current portfolio's average delay in delivering capability increased by almost 2 months over the past year, yet 49 percent of programs in the 2016 portfolio intend to declare, or have declared, initial operational capability on the basis of limited or, in a few cases, no operational testing.

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[11] GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-16-329SP (Washington, D.C.: Mar. 31, 2016).

[12] When we refer to spent funding, we are referring to funds that may have been expended, obligated, and, or allotted.

Our analysis of DOD's 2016 portfolio allows us to make the following 11 observations:

Cost and Schedule Performance Observations

Changes to the portfolio

1. The 2016 portfolio consists of 78 programs, down from 79, which will cost over $1.46 trillion to acquire. Over the past year, the cost estimates of these programs increased by $9.4 billion, or less than 1 percent.[a]
2. Development and procurement costs increased by $3.7 and $5.6 billion respectively. Three programs—the Evolved Expendable Launch Vehicle, the Next Generation Operational Control System, and the Littoral Combat Ship—account for $2.2 billion of the aggregate development cost increase. The three largest procurement cost increases were in shipbuilding programs, which all increased their procurement quantities.
3. The amount of future funding needed to complete the portfolio's planned development activities and procure all planned units—$573.6 billion–decreased.[b] Of this future funding, $546 billion is for procurement and $27.6 billion is for development. The remaining funds for development total less than half the amount that remained 10 years ago. The current portfolio's average delay in delivering capability increased by almost 2 months over the past year.

Factors that explain the changes

4. The entire portfolio has experienced over $484 billion in cost growth since programs established their first full estimates. However, $476 billion of this growth occurred 5 or more years ago. The portfolio realized 60 percent of its cost growth, or $259 billion, after production start. These post-production cost increases may indicate that programs start production without having demonstrated that a production-representative prototype will work as intended. Programs started before 2010 make up a majority of the total cost growth since first full estimates.
5. The portfolio realized a buying power gain of $10.7 billion, although more programs overall lost buying power over the past year.[c]
6. As measured against specific cost growth metrics, 78 percent of programs meet the threshold for less than 10 percent cost growth over the past 5 years. However, fewer programs meet the metrics for realizing less than 2 percent cost growth over 1 year or for less than 15 percent cost growth from initial estimates.

Post-Reform Program Observations

7. Nineteen programs started development after the implementation of acquisition reforms in 2010. These programs decreased their costs by $3.4 billion over the past year—continuing a trend that began in 2015—but experienced an average delay to delivering capability of over 3 months.
8. These 19 programs represent about one-quarter of the programs in the whole portfolio, but account for only 10 percent of the portfolio's total acquisition cost.
9. Over the past year, total acquisition cost changes for these 19 programs show a similar profile to the cost changes affecting the remaining 59 programs. Further, an inordinately large program in each group—Joint Light Tactical Vehicle and F-35 Lightning II—drives a majority of the overall cost changes.

Other Observations

10. Forty-nine percent of programs intend to or have declared initial operating capability on the basis of limited or, in a few cases, no operational testing. Specifically, 9 percent declared initial operating capability before beginning testing, and 40 percent did or plan to declare initial operating capability before testing completes. Programs declaring initial operational capability prior to completing initial operational test and evaluation risk fielding systems that are later found to be ineffective or unsuitable for missions.

11. The leading companies DOD relies on to develop and produce military capabilities have consistently shown strong market performance, which indicates that investors expect the performance of these companies to be strong for some time to come. Stock prices for these companies have increased significantly over time—outperforming other market sectors over the past 1 year and 5 years.

Source: GAO analysis of DOD data. | GAO-17-333SP

[a] All dollar figures are in fiscal year 2017 constant dollars, unless otherwise noted.

[b] Details on program costs used for this analysis are provided in appendix I. For more information on the portfolio's performance since their estimates 1 year and 5 years ago, see appendix II.

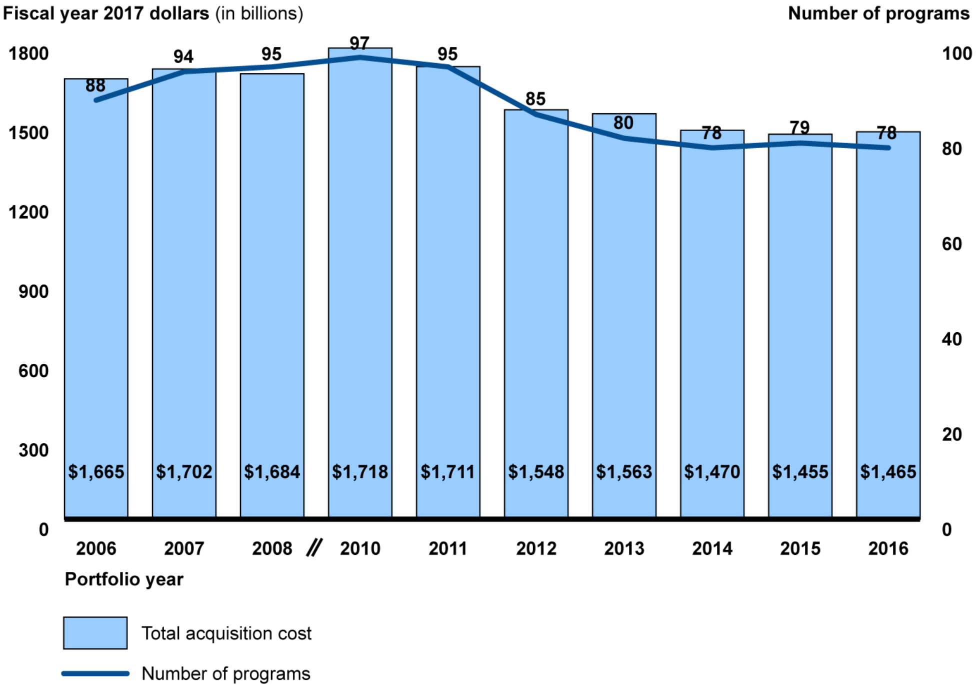
[c] Buying power can be defined as the amount of goods or services that can be purchased given a specified level of funding.

Changes to the portfolio

1. **The 2016 portfolio consists of 78 programs, down from 79, which will cost over $1.46 trillion to acquire. Over the past year, the cost estimates of these programs increased by $9.4 billion or less than 1 percent.** Our analysis shows that this cost increase is primarily due to three factors:

    - First, three programs left the portfolio—taking away $17 billion from the total cost—while two new programs expected to cost $16.9 billion in total entered the portfolio. Of the three programs that exited the portfolio, the Joint Tactical Networks and the RQ-4A/B Global Hawk Unmanned Aircraft System completed planned development and procurement. One program, the Joint Standoff Weapon, was terminated. Two Army programs began system development and entered the portfolio: the Armored Multi-Purpose Vehicle and the Joint Air-to-Ground Missile. The Joint Air-to-Ground Missile program was in the materiel solution and technology development phase before its system development start but the Armored Multi-Purpose Vehicle program entered development with its system development start in December 2014. Figure 2 shows the changes in total cost and number of programs within DOD's portfolio of major weapon acquisitions since 2006.

Figure 2: DOD Portfolio Cost and Size, 2006-2016



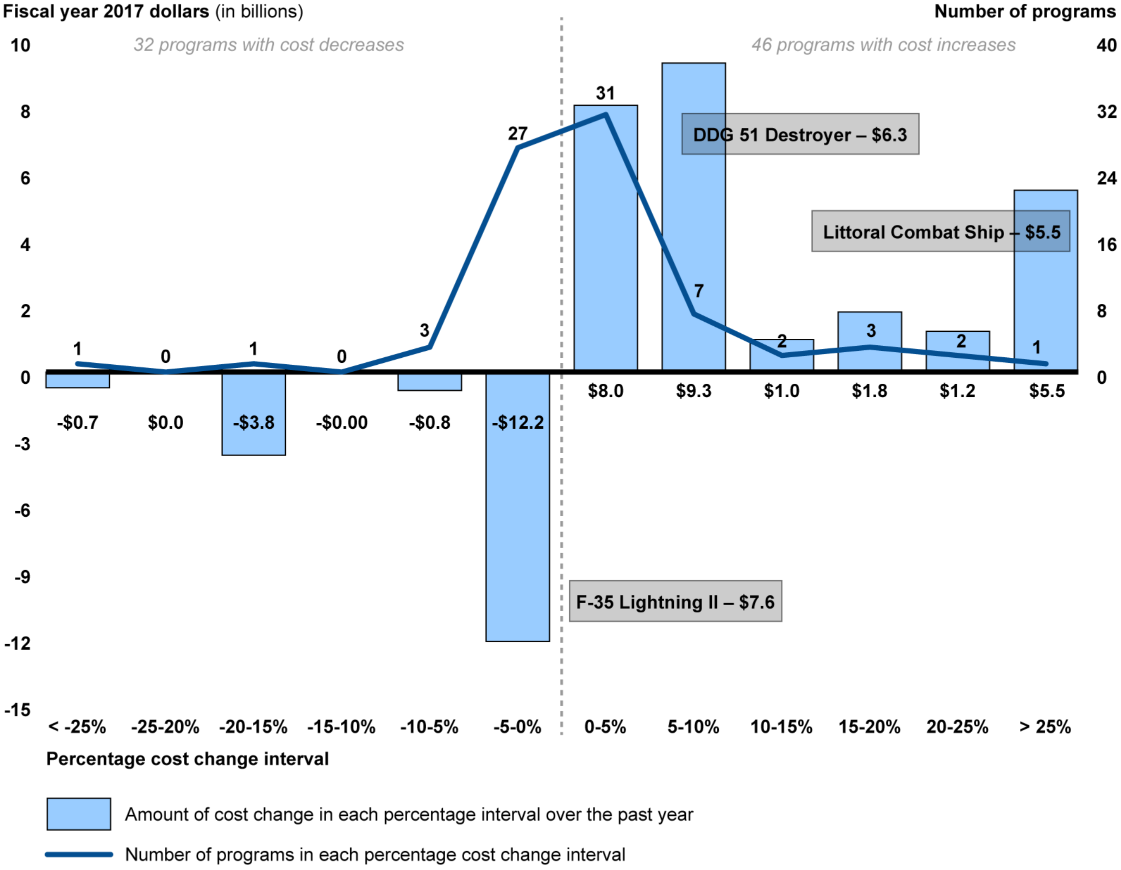
Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: DOD did not issue SARs in 2009, which precludes us from having the cost baseline information necessary to include 2009 in this analysis.

- Second, two of the portfolio's joint programs decreased their total cost significantly. The F-35 Lightning II's total cost decreased by $7.6 billion over the past year with no changes to its planned procurement quantities. Much of these savings were generated by changes in estimating assumptions for savings in future lots. The Joint Light Tactical Vehicle program decreased its total quantities and the total program's cost decreased by $3.8 billion not due to the quantity changes.
- Third, a majority of programs experienced cost increases over the past year. Of the 78 programs, 46 saw $26.8 billion in cost increases while 32 programs experienced $17.5 billion in cost decreases. Most programs' cost change over the past year were between a 0 to 5 percent change, whether it was an increase or a decrease. However, we identified a handful of programs with percent cost changes greater than 20 percent, including the Littoral Combat Ship and the Remote Minehunting System. Figure

3 shows the distribution of these cost changes across the entire portfolio.

Figure 3: Distribution of the 1-year Change in Total Acquisition Cost for the 2016 Portfolio



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: Any percentage that is an exact multiple of 5 is put in the higher category.

Of the 46 programs that experienced cost increases in the past year, 27 realized a total of $4.6 billion in increases that were not due to quantity increases. Another 18 programs saw their costs increase by $22.2 billion while also increasing their planned quantities. One program—the Joint Air-to-Surface Standoff Missile had a cost increase of $59.7 million, but also a quantity decrease.

Of the 32 programs that experienced cost decreases in the past year, 24 realized a total of $10 billion in decreases that were not due to quantity decreases. Another 7 programs saw decreases of $6.8 billion due to quantity decreases, while one program—AIM-120 Advanced

Medium Range Air-to-Air Missile—had a cost decrease of $654.7 million despite an increase in quantity.

2. **Development and procurement costs increased by $3.7 and $5.6 billion, respectively. Three programs—the Evolved Expendable Launch Vehicle, the Next Generation Operational Control System, and the Littoral Combat Ship—account for $2.2 billion of the aggregate development cost increase. The three largest procurement cost increases were in shipbuilding programs, which all increased their quantities.** Table 1 outlines the changes in funding for the 2016 portfolio.

Table 1: Changes in DOD's 2016 Portfolio of 78 Major Defense Acquisition Programs over the Past Year

Fiscal year 2017 dollars (in billions)

	Estimated portfolio cost in 2015	**Estimated portfolio cost in 2016**	**Estimated cost change since 2015**	**Percentage change since 2015**
Total estimated research and development cost	286.0	289.7	3.7	1.3
Total estimated procurement cost	1,156.3	1,162.0	5.6	0.5
Total estimated acquisition cost[a]	1,455.4	1,464.7	9.4	0.6

Source: GAO analysis of DOD data. | GAO-17-333SP

Note: Some numbers may not sum due to rounding.

[a] In addition to research and development and procurement costs, total acquisition cost includes acquisition-related operation and maintenance and system-specific military construction costs.

The current portfolio's development and procurement cost increases over the past year resulted in a total increase of $9.4 billion. Of the 78 programs, 52 increased their development costs over the past year. Increases for 18 of these programs were under $10 million each, and the remaining range between $10 million and $1.1 billion.

The three largest development cost increases included two space programs and one shipbuilding program. The largest development cost increase was on the Evolved Expendable Launch Vehicle program. Its cost increased by $1.1 billion to conduct new engine development activities. The Next Generation Operational Control System's costs increased by $575 million to address technical issues in its development. Further, Littoral Combat Ship development costs increased by $469 million to fund engineering support, test and evaluation, and training development needs in support of its new frigate-related design enhancements.

Three shipbuilding programs increased the quantity of ships they plan to buy, which increased their procurement costs and, subsequently, total acquisition costs significantly. Total acquisition costs for the DDG 51 Arleigh Burke Class Guided Missile Destroyer, the Littoral Combat Ship, and the SSN 774 Virginia Class Submarine increased by $6.3 billion, $5.5 billion and $3.4 billion, respectively. These increases are in contrast to the decreases in procurement costs and total acquisition costs that we observed in our 2016 assessment.

3. **The amount of future funding needed to complete the portfolio's planned development activities and procure all planned units—$573.6 billion—decreased. Of this future funding, $546 billion is for procurement and $27.6 billion is for development. The remaining funds for development total less than half the amount that remained 10 years ago.[13] The current portfolio's average delay to delivering capability increased by almost 2 months over the past year.** The aforementioned cost changes indicate that more of the portfolio's total acquisition cost is spent and unavailable for allotment. The future funding available to conduct planned development activities and acquire expected units is 40 percent of the total development and procurement funding in the current portfolio. By contrast, in 2006, the amount of future funding available was over $966 billion, or 59 percent, of the portfolio's total development and procurement cost. Figure 4 shows the change in the portfolio's future funding and funding invested as a share of the portfolio's total acquisition cost since 2006.

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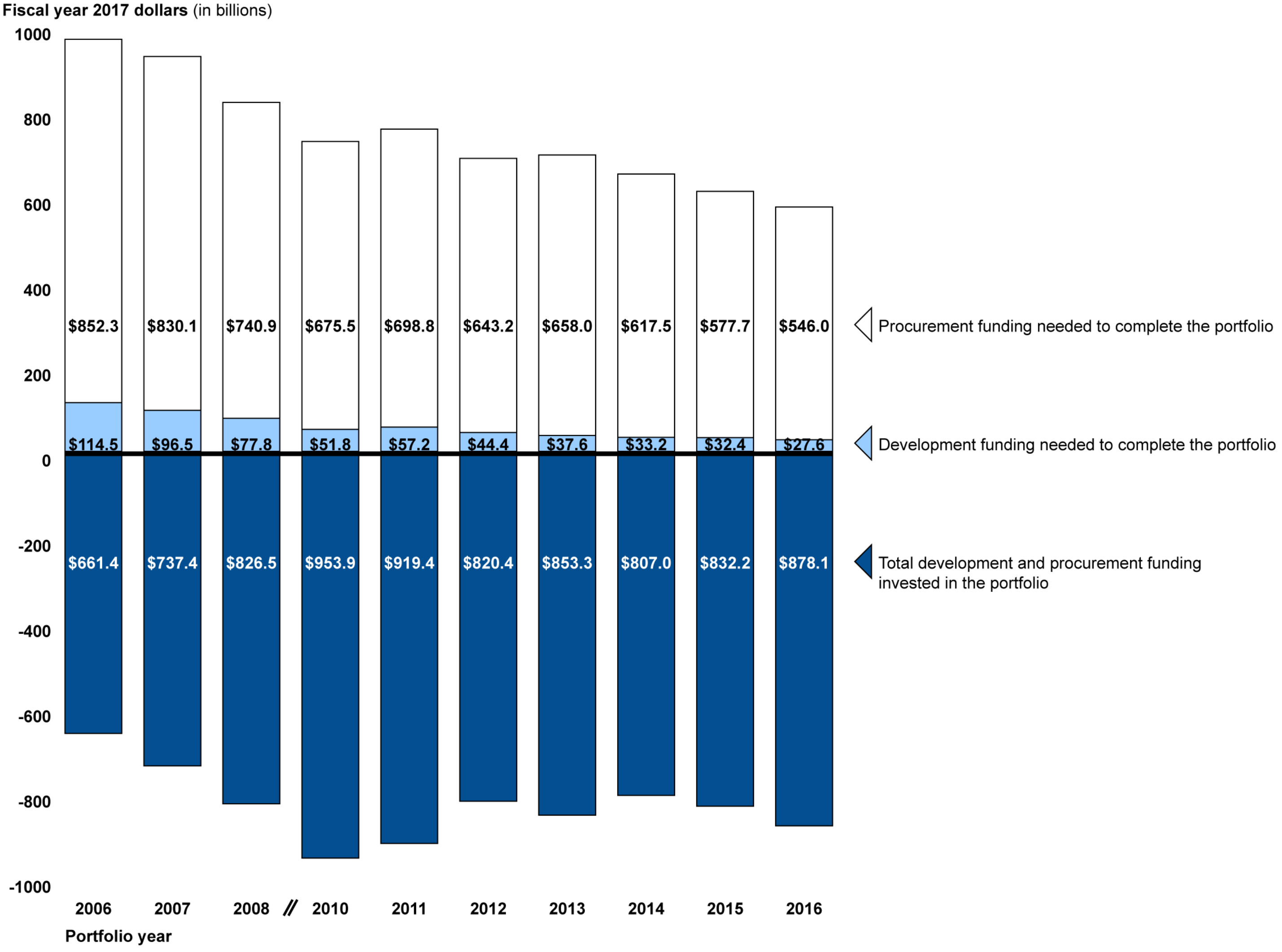
[13] Other costs include military construction and acquisition operations and maintenance, which account for $13.1 billion of the 2016 portfolio's total acquisition cost.

Figure 4: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2006-2016



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: DOD did not issue SARs in 2009, which precludes us from having the cost baseline information necessary to include 2009 in this analysis.

In addition, the amount of future development funding in the current portfolio is less than half of what it was 10 years ago. The $27.6 billion in future development funding is 4.8 percent of the available future funding, compared to the amount available in 2006, which was over 11.8 percent.

Some programs’ costs increased due to schedule delays. When measuring the current portfolio’s schedule performance over the past year, we found that initial operational capability delays increased by almost 2 months and now stand at 30.8 months cumulative beyond initial estimates.[14] Of the 78 programs in the 2016 portfolio, 11 suffered delays that contributed to the overall portfolio delay. Seven of these 11 programs reported a delay of 6 months or more—delays significant enough to require DOD to report them as a breach to the acquisition program baseline. The largest delay—2.5 years—was in the Remote Minehunting System program, which DOD has since canceled.

Factors that explain the changes

4. **The entire portfolio has experienced over $484 billion in cost growth since programs established their first full estimates.[15] However, $476 billion of this growth occurred 5 or more years ago. The portfolio realized a majority of its cost growth, or $259 billion, after production start. Programs started before 2010 make up a majority of the total cost growth since first full estimates.** At the start of system development and with the approval of the Milestone Decision Authority, programs establish an acquisition program baseline to measure their performance against. This baseline includes a cost estimate for the proposed solution that identifies estimated costs over the full life of the program, including development and production. Our analysis of the 2016 portfolio found that programs’ costs grow throughout development, but that a majority of this cost growth occurs after programs have started production. Figure 5 illustrates the portfolio’s development and procurement cost growth as incurred between key program milestones.

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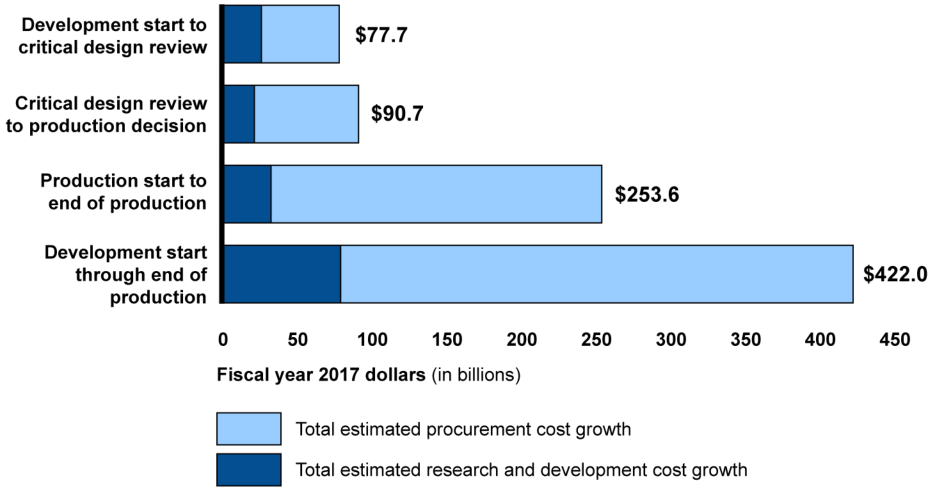
[14] When calculating this delay, we obtained schedule information for the cycle time from program start to initial operational capability as reported in the previous year and contrasted it with the current schedule.

[15] The first full estimate is generally the cost estimate established at the start of system development, for more information see Appendix I. For more information on the portfolio’s performance since first full estimates, see Appendix III.

Figure 5: Development and Procurement Cost Growth between Key Milestones for Programs Included in DOD's 2016 Portfolio



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: To accommodate shipbuilding programs in this analysis, we correlated detail design contract awards, fabrication starts, and lead ship deliveries with development start, critical design review, and production start, respectively.

In the first phase of development, between the start of a program and critical design review, programs realized $77.7 billion in development and procurement cost growth, $25.7 billion of which was solely development cost growth. In the next phase, or between the critical design review and the initial production decision, programs realized an additional $90.7 billion in cost growth—$21 billion in development funding and $69.7 billion in procurement funding. Finally, after their production decisions, programs realized another $253.6 billion in cost growth, which is a 60 percent increase over their initial development and procurement estimates.

A majority of programs' development and procurement cost growth occurs after they have started production. These significant post-production cost increases—particularly within development funds—may indicate that programs start production without having demonstrated that a fully integrated, capable production-representative prototype will work as intended. Alternatively, post-production increases to procurement costs within programs may be explained, in part, by unplanned quantity increases.

5. **The portfolio realized a buying power gain of $10.7 billion, although more programs overall lost buying power over the past year.** To understand the changes in the portfolio's total cost over the

past year, the effect of changes in quantity on individual programs must be analyzed and understood. In general, buying power can be defined as the amount of goods or services that can be purchased given a specified level of funding. To determine changes in buying power, the effects of quantity changes must be isolated from other factors that affect cost. For example, a program's cost can increase solely because of additional quantities. While that does represent a cost increase, it does not necessarily indicate acquisition problems or a loss of buying power. Alternatively a program's cost can decrease due to a reduction in quantity and may still experience a buying power gain or loss. Table 2 shows our calculation of how programs' cost and quantity changes affected their buying power.

Table 2: Buying Power Analysis for the 2016 Portfolio

Fiscal year 2017 dollars, billions

	Number of programs	GAO calculated cost change due to quantity changes	Actual procurement cost change	GAO calculated cost change not attributable to quantity changes
Programs that gained buying power	**33**	**1.8**	**-15.1**	**-16.9**
Procurement cost decreased with no quantity change	24	0.0	-13.6	-13.6
Quantity increased with less cost increase than anticipated	6	3.4	1.5	-2.0
Quantity decreased with more cost decrease than anticipated	3	-1.7	-3.1	-1.4
Programs that lost buying power	**40**	**14.6**	**20.7**	**6.2**
Procurement cost increased with no quantity change	25	0.0	2.6	2.6
Quantity increased with more cost increase than anticipated	12	15.8	19.2	3.4
Quantity decreased with less cost decrease than anticipated	3	-1.2	-1.1	0.2
Programs with no change in buying power	**5**	0.0	0.0	0.0
Portfolio totals	**78**	**16.3**	**5.6**	**-10.7**

Source: GAO analysis of DOD data. | GAO-17-333SP

Note: GAO calculated cost change "due" to quantity changes as the change in quantity over the last year multiplied by the average procurement unit cost and we calculated the cost change "not due" to quantity changes as the current acquisition quantity times the change in average per unit costs. If changes in quantity affect per unit cost, those changes will appear in the cost change "not due" to quantity changes column.

According to our calculation of cost versus quantity changes, we would have expected procurement costs in the portfolio to increase by $16.3 billion. Instead, procurement costs for the portfolio have increased by $5.6 billion over the past year, indicating that programs found efficiencies in other areas to offset the buying power losses. This net result is largely due to Army and Air Force programs gaining buying power and is offset by buying power losses in Navy programs.

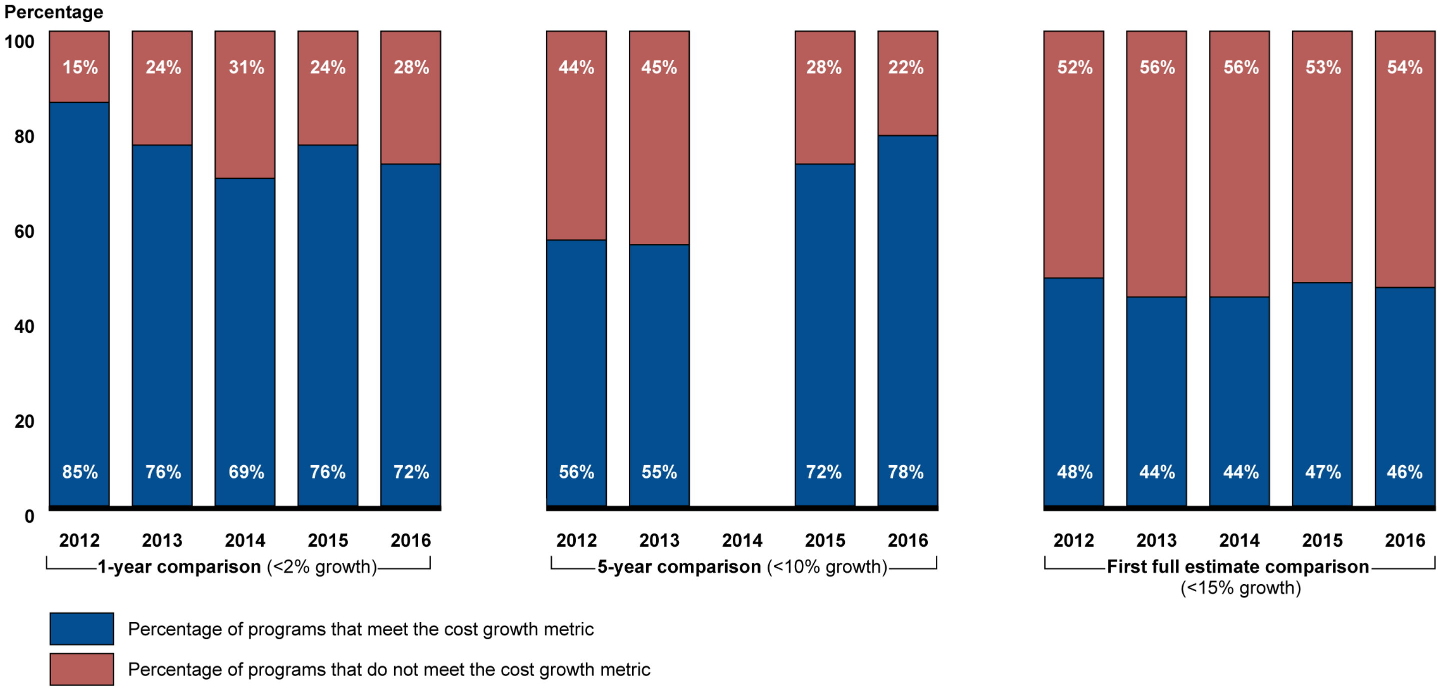
Our analysis shows that 33 programs increased in buying power over the past year and reduced procurement costs by a total of $15.1 billion. This total is the net amount of cost change given increases and decreases due to other program efficiencies. Twenty-four of these 33 programs decreased procurement costs with no change in their procurement quantity, indicating that they found efficiencies elsewhere. For example, the 2 DOD-lead programs—F-35 Lightning II and the Joint Light Tactical Vehicle—had significant decreases in total cost not due to quantity changes, which also drove the overall buying power gain. Some of these programs reported identifying significant realized and expected “should-cost” savings that resulted in a reduction of procurement cost or offset the cost of additional quantities.

Six programs are buying additional quantities at lower prices. In other words, their planned procurement quantities increased, but the corresponding procurement cost did not increase or was offset, at least in part, by other efficiencies. For example, the M109A7 Family of Vehicles program plans to procure 12 additional vehicles. Our analysis indicates that if the cost increase was what we expected, the program’s procurement costs should have risen by $132 million. Instead, the program’s procurement cost only increased by $123 million and the program realized a buying power gain.

Conversely, 40 programs lost buying power in the past year with actual procurement cost increases of $20.7 billion. By our calculations, the net result of quantity changes on these programs should have resulted in a $14.6 billion cost increase. Procurement cost increases not related to quantity changes generated $2.6 billion in additional costs and a net buying power loss. Contributing to this were 25 programs that lost buying power as their procurement costs increased with no change in quantities, an indication of inefficiencies within these programs. For example, the Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios program lost buying power as it experienced a procurement cost increase of $310 million over the past year with no change in its planned procurement quantity. Twelve programs increased their planned procurement quantities but incurred a higher than expected procurement cost increase, indicating that they lost efficiencies elsewhere. The remaining 3 programs reported decreases in their initial quantities; however, the cost reductions on these programs are less than expected by our calculations.

6. **As measured against specific cost growth metrics, 78 percent of programs meet the threshold for less than 10 percent cost growth over the past 5 years. However, fewer programs meet the metrics for realizing less than 2 percent cost growth over 1 year or for less than 15 percent cost growth from initial estimates.** In December 2008, we discussed and agreed with DOD and the Office of Management and Budget on a set of outcome metrics and goals to measure program cost performance over time. The metrics are intended to measure cost performance on a percentage basis over three defined periods: the preceding year, the preceding 5 years, and since first full estimates were established. We have reported on these outcomes since 2011 and figure 6 shows how the performance of the current portfolio compares to our prior assessments.

Figure 6: Comparison of the Cost Performance of DOD's 2012-2016 Portfolios



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: DOD did not issue Selected Acquisition Reports in 2009, which precludes us from having the cost baseline information necessary to assess the 5-year performance of the 2014 portfolio.

We found that 78 percent of programs kept their cost growth under 10 percent over the past 5 years, which is a six point improvement over the 2015 portfolio. The number of programs in the portfolio meeting this metric since 2013 has been increasing. While the 5-year trend is encouraging, less than half of the programs in the portfolio are able to keep their cost growth under 15 percent from their initial cost estimates. Similarly, the number of programs in the 2016 portfolio that meet the 1-year metric by limiting their total acquisition cost growth to less than 2 percent decreased from 76 percent to 72 percent.

Post-reform program observations

7. **Nineteen programs started development after the implementation of acquisition reforms in 2010. These programs decreased their costs by $3.4 billion over the past year—continuing a trend that began in 2015—but experienced an average delay to delivering capability of over 3 months.** Since 2010, DOD has taken steps to improve the outcomes of defense acquisition programs including implementing the reforms in WSARA and DOD's "Better Buying Power" initiatives.[16] As a group, these 19 programs realized an overall cost decrease, but also a schedule delay. The cost decrease is primarily due to a large decrease on one program—the Joint Light Tactical Vehicle—and the net result of cost changes on the remaining 18 programs. During the past year, 9 programs reported cost decreases totaling $4.8 billion, while 10 programs reported cost increases totaling approximately $1.4 billion; together, this resulted in an overall cost decrease of $3.4 billion. Table 3 compares statistics for programs in the 2016 portfolio that began before 2010 (59) to statistics for the programs initiated in or after 2010 (19), once reforms were implemented.

Table 3: Observations on Programs Initiated before 2010 and in or after 2010 That Together Comprise DOD's 2016 Portfolio

(All dollars in fiscal year 2017 dollars)

Programs initiated before 2010		Programs initiated in or after 2010	
Number of programs	59	Number of programs	19
Total acquisition cost	1.32 trillion	Total acquisition cost	147.1 billion
1-year cost change	12.8 billion increase	1-year cost change	3.4 billion decrease
Cost change since original estimate	486.3 billion increase	Cost change since original estimate	3.5 billion decrease
Percentage of programs with cost increases over the past year	61	Percentage of programs with cost increases over the past year	53

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[16] Many of these reforms and initiatives have been incorporated into DOD Instruction 5000.02.

(All dollars in fiscal year 2017 dollars)

Programs initiated before 2010		**Programs initiated in or after 2010**	
Total 1-year cost increases	25.4 billion	Total 1-year cost increases	1.4 billion
Percentage of programs with cost decreases over the past year	39	Percentage of programs with cost decreases over the past year	47
Amount of 1-year cost decreases	12.6 billion	Amount of 1-year cost decreases	4.8 billion
Schedule accelerated over the past year	1.3 months	Schedule delay over the past year	3.1 months

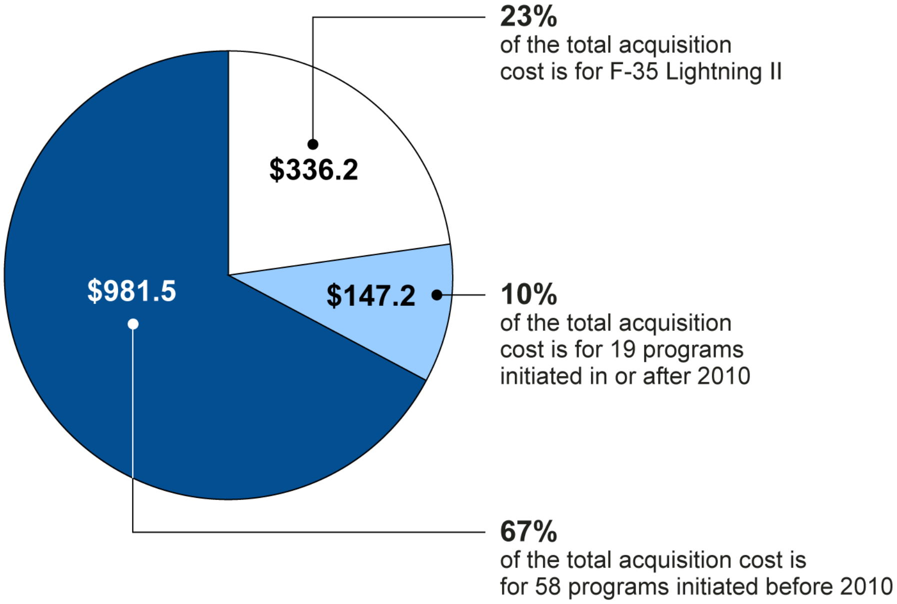
Source: GAO analysis of DOD data. | GAO-17-333SP

The total acquisition cost of the 59 and 19 programs, respectively, is $1.32 trillion and $147.1 billion. Of these amounts, $257.1 billion and $32.6 billion are development funding, or roughly 20 percent for each group of programs. Each group also had more programs with cost increases than not, and each generally had a similar percentage of programs with cost increases and decreases.

Of the 19 programs initiated in 2010 or later, 3 reported a delay of 1 year or more to their initial operational capability. The Next Generation Operational Control System, Joint Light Tactical Vehicle, and Small Diameter Bomb Increment II programs reported delays of 2 years, over 1 year, and 1 year respectively. We found that a similar proportion of programs initiated before 2010 also reported delays. Schedule delays may cause a program’s cost to increase. However, delays may also indicate that the program recognizes it needs more time before exiting development to be ready to continue into later phases, such as testing and production.

8. **These 19 programs represent about one-quarter of the programs in the whole portfolio, but account for only 10 percent of the portfolio’s total acquisition cost.** Many of the programs that started system development in or after 2010 may not have been in development long enough to realize similar cost growth as the rest of the portfolio. Nonetheless, all but 2 of these programs—the Combat Rescue Helicopter and the Intercontinental Ballistic Missile Fuze Modernization—have held a critical design review or started system development concurrent with a production decision and are now at a point in the acquisition cycle where other programs have experienced significant cost growth, as we identified above. Nine of the 19 programs held a critical design review in the past 3 years. The estimated cost for these 19 programs is less than half the cost of the F-35 Lightning II, as shown in figure 7 below.

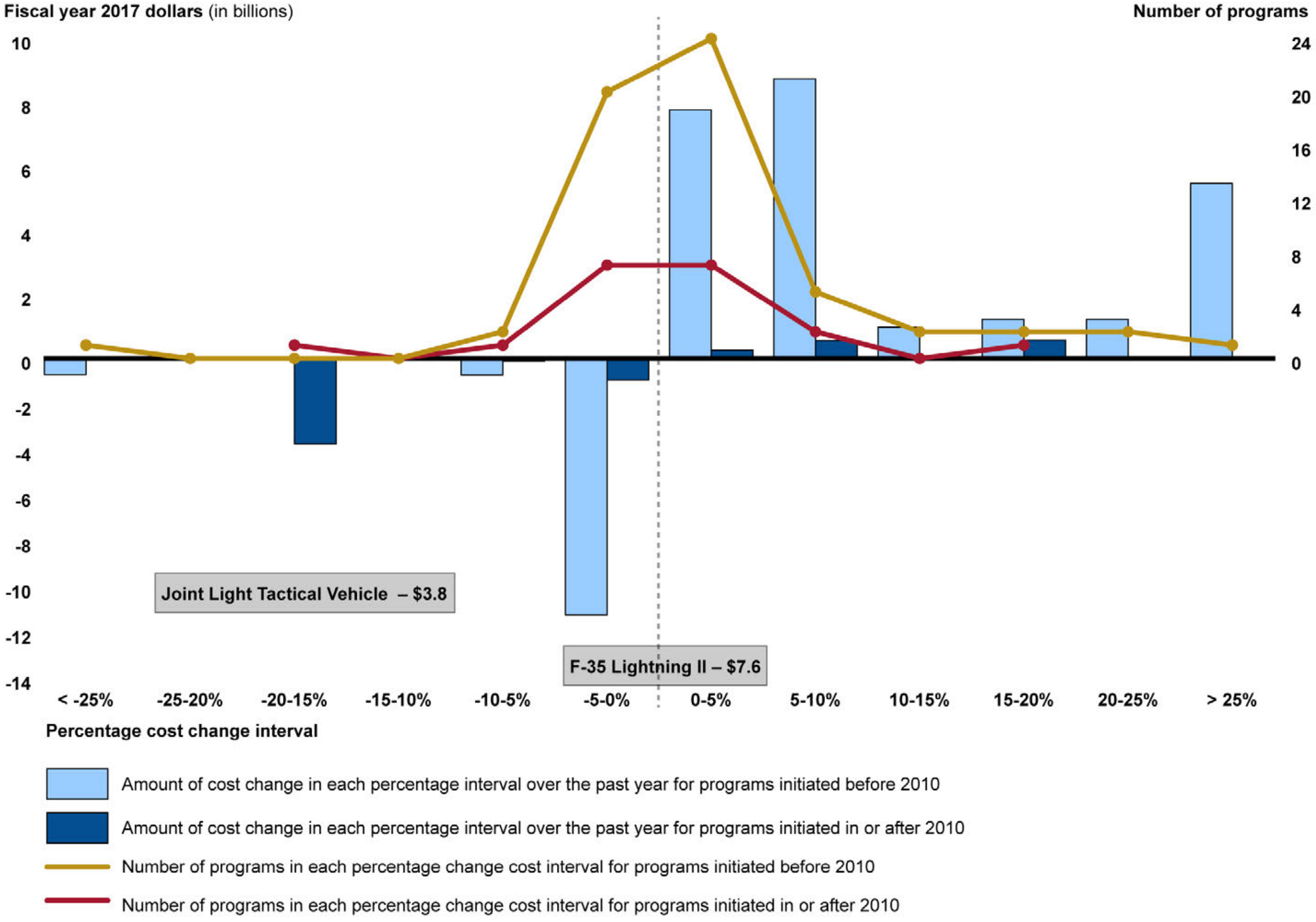
Figure 7: Ten Percent of DOD's Total Acquisition Cost Is for the 19 Programs Initiated in or after 2010 and 90 Percent Is for the Remaining 58 Programs and the F-35 Lightning II (fiscal year 2017 dollars in billions)



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

9. **Over the past year, total acquisition cost changes for these 19 programs show a similar profile to the cost changes affecting the remaining 59 programs. Further, an inordinately large program in each group—Joint Light Tactical Vehicle and F-35 Lightning II—drives a majority of the overall cost change.** We analyzed the cost and schedule changes for the 19 programs started after acquisition reforms to compare their performance as a group to the remaining 59 programs in the portfolio. We found that, in many ways, they are performing similarly in terms of cost. For example, a majority of programs in each group saw small percent changes in their total acquisition cost growth resulting in similarly shaped bell curves in figure 8. Figure 8 also illustrates the distribution of total acquisition cost change amount in each percent change interval over the past year for both sets of programs.

Figure 8: Distribution of the 1-year Change in Total Acquisition Cost for the Programs Initiated before 2010 and the Programs Initiated in or after 2010



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: Any percentage that is an exact multiple of 5 is put in the higher category.

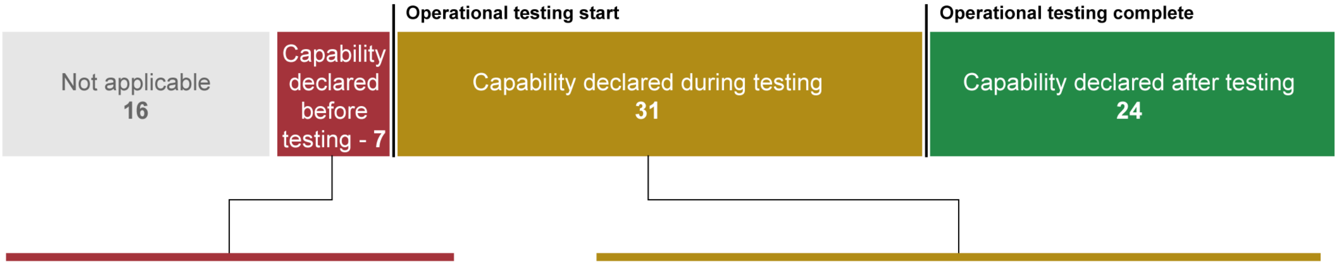
The distribution curve of each set of programs is similar with a majority of programs between a 5 percent decrease and 5 percent increase over the past year and only a few programs with large percent changes. We also identified the Joint Light Tactical Vehicle and F-35 Lightning II as outlier programs. These 2 programs had significant cost decreases over the past year that disproportionately affected the net cost change for their respective groups.

Other observations

10. **Forty-nine percent of programs intend to or have declared initial operational capability on the basis of limited or, in a few cases, no operational testing. Specifically, 9 percent declared initial operational capability before beginning testing, and 40 percent did or plan to declare initial operating capability before testing completes. Programs declaring initial operational capability prior to completing initial operational test and evaluation risk fielding systems that are later found to be ineffective or unsuitable for missions.** According to DOD policy, the appropriate authority will declare initial operational capability when the unit or organization has been equipped and trained and is determined to be capable of conducting mission operations. The specifics for a particular system's initial operational capability are defined in its Capability Development Document and Capability Production Document, which DOD requires before a program enters system development and production, respectively. For instance, when drafting a Capability Development Document, programs describe the types and initial quantities of assets required to attain initial operational capability. They also identify the operational units such as the service or other government agencies that will employ the capability. Initial operational capability definitions in these documents, however, may or may not include the Director, Operational Test and Evaluation's assessment of the system's effectiveness and suitability.

    Typically, initial operational capability and operational test and evaluation both occur during a program's production and deployment phase. Initial operational test and evaluation is intended to evaluate a system's effectiveness and suitability under realistic combat conditions before a full-rate production decision. However, DOD's Instruction 5000.02 may be tailored to meet program objectives, and DOD's Test and Evaluation Management Guide notes that initial operational capability is usually determined by the service. Consequently, programs can declare initial operational capability on the basis of full, partial, or no initial operational test and evaluation. Our analysis found that nearly half the programs in the current portfolio declared, or plan to declare, initial operational capability before or during testing. Figure 9 illustrates our analysis of the relationship between initial operational capability and initial operational test and evaluation in current DOD programs.

Figure 9: Programs’ Timing of Declaring Initial Operational Capability and Completing Initial Operational Test and Evaluation



Cooperative Engagement Capability (CEC)
Combat Rescue Helicopter (CRH)
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)
Global Broadcast Service (GBS)
Ground/Air Task Oriented Radar (G/ATOR)
Littoral Combat Ship (LCS)
SSN 774 Virginia Class Submarine (SSN 774)

AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)
AH-64E Apache New Build (AH-64E New Build)
AH-64E Apache Remanufacture (AH-64E Remanufacture)
Armored Multi-Purpose Vehicle (AMPV)
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)
DDG 1000 Zumwalt Class Destroyer (DDG 1000)
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)
E-2D Advanced Hawkeye Aircraft (E-2D AHE)
EA-18G Growler Aircraft (EA-18G)
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)
F-35 Lightning II Program (F-35)
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)
Integrated Defensive Electronic Countermeasures (IDECM) Block 4
Joint Air-to-Ground Missile (JAGM)
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)
KC-46 Tanker Modernization Program (KC-46A)
LHA 6 America Class Amphibious Assault Ship (LHA 6)
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)
M109A7 Family of Vehicles (M109A7 FOV)
MH-60R Multi-Mission Helicopter (MH-60R)
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)
Multifunctional Information Distribution System (MIDS)
Navy Multiband Terminal (NMT)
Next Generation Operational Control System (GPS OCX)
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)
Remote Minehunting System (RMS)
Ship to Shore Connector Amphibious Craft (SSC)
Small Diameter Bomb Increment II (SDB II)
Space Fence Ground-Based Radar System Increment 1

Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Note: The quantity allotments within the figure reflect programs that have declared initial operational capability as well as some that have not yet declared it, but have identified when they expect to make the declaration in relation to their initial operational test and evaluation plans.

Programs declaring initial operational capability prior to completing full operational testing risk finding deficiencies in testing that may need to be corrected, which could add to a program’s cost and schedule post-production. For example, the Navy declared initial operational capability for the Littoral Combat Ship in 2014 while facets of the ship’s capabilities—including most mission equipment—were still undergoing developmental testing. Essentially, declaring initial operational capability signals that the ship is ready to conduct missions. However, in the case of the Littoral Combat Ship, we testified in December 2016 that the Navy had fallen short of demonstrating that either of the program’s two seaframe designs, or its three mission packages, met the minimum level of capability defined at the beginning of the program.[17] Further, since declaring initial operational capability, the program has identified significant performance limitations affecting both seaframes and mission packages, consequently leading it to postpone initial operational test and evaluation. These deficiencies have contributed, in part, to the Navy truncating the program at fewer quantities than originally planned and moving to a new design frigate.

Although many programs are not utilizing their operational testing results to inform their initial capability declarations, some are. Thirty-one percent of programs either achieved or plan to achieve initial operational capability after they have completed operational testing. Sixteen programs either do not track an initial operational capability date or have completed or planned operational test dates.

11. **The leading companies DOD relies on to develop and produce military capabilities have consistently shown strong market performance, which indicates that investors expect the performance of these companies to be strong for some time to come. Stock prices for these companies have increased significantly over time—outperforming other market sectors over the past 1 year and 5 years.** These sustained increases have occurred irrespective of cost and schedule outcomes in the defense acquisition portfolio, which these companies help support. DOD relies on the defense industrial base to provide capabilities that equip forces to meet mission requirements. The defense industrial base consists of privately owned companies of various sizes to which DOD awards contracts to develop and produce its major weapon systems. The defense industrial base works in tandem with DOD to provide key capabilities to our warfighters.

    We observed that regardless of whether DOD programs experienced cost increases, decreases, or stability, nearly every leading defense contractors’ stock price generally increased. This provides an

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[17] GAO, *Littoral Combat Ship and Frigate: Slowing Planned Frigate Acquisition Would Enable Better-Informed Decisions*, GAO-17-279T (Washington, D.C.: Dec. 8, 2016).

indication that investors expect the performance of these companies to be strong for some time to come. We selected six publicly-traded defense contractors developing and delivering the largest DOD acquisition programs and analyzed their stock prices and their DOD programs' cost changes over the past year and 5 years.[18] These contractors account for 73 percent of the contracts for weapon systems in the current portfolio.

In comparison, these defense companies' stock prices have grown at consistently higher rates over the past year and 5 years than the S&P 500 and the Industrials sector of the S&P 500.[19] DOD also reported last year that its major defense companies have remained profitable, even in a DOD business environment that has increasingly attempted to more closely link contractor profits to performance in defense acquisition programs.[20]

Cost growth in the portfolio is undesirable from DOD's perspective as, in a constrained funding environment, DOD must make tradeoffs to fund cost growth on existing programs, rather than starting new programs or upgrading existing programs. For defense contractors, the effects of cost growth are partially determined by the type of contract awarded. A range of contract types may be used that vary the cost risk assumed by contractors and the government, depending on numerous factors. In addition, incentives can be used to incentivize the contractor to, among other things, control costs. DOD stated in its 2016 annual report on the performance of the Defense Acquisition System that, "the real issue is how effective the incentives are for each contract type based on the situation at hand."

For example, a DOD program may award a firm-fixed-price contract if the expected cost of the effort is well understood. A firm-fixed-price contract provides for a price that is not subject to change on the basis of the contractor's cost experience in performing the contract. This type of contract places most of the risk for cost growth on the contractor and provides incentive for the contractor to control costs and perform effectively. Some fixed-price type contracts provide for cost incentives. For example, we found in April 2015 that the KC-46A

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[18] We did not include all defense contractors nor did we include any smaller defense contractors in our assessment.

[19] Indices used are based on Standard & Poor's Global Industry Classification System.

[20] Under Secretary of Defense, Acquisition, Technology, and Logistics, *Performance of the Defense Acquisition System: 2016 Annual Report* (Washington D.C.: Oct. 24, 2016).

Tanker Modernization (KC-46A) program is being developed under a fixed-price incentive (firm target) contract, which the Air Force awarded to Boeing in 2011 because it considered integrating largely mature military technologies onto an aircraft designed for commercial use to be a relatively low risk effort.[21] This contract type provides for adjusting profit and establishing the final contract price by application of a formula based on the relationship of total final negotiated cost to total target cost. The final price is subject to a price ceiling, negotiated at the outset, which is the maximum that may be paid to the contractor, except for any adjustment under other contract clauses. By December 2015, both the contractor and government estimated that costs would be over the contract ceiling price. As such, Boeing will generally assume all responsibility for the additional costs.

Alternatively, a program might award a cost-reimbursement contract if costs are less known and there is more risk for cost growth. The cost-plus incentive fee type contract is the most common cost-reimbursement contract type awarded in the current portfolio. Also, programs may use a combination of contract types to take advantage of the benefits each affords. Theoretically, no matter the contract type, if the contractor performs as expected, it should generally earn profits which could affect the contractors' stock prices. However, there are also cases in which the contractor may underperform, and subsequently earn fewer profits than expected.

The contractors in our analysis have business outside of their DOD contracts that also factor into their overall market performance. As such, we are not correlating the contractors' performance on their DOD contracts with their stock prices.

Observations about DOD's Implementation of Key Acquisition Reform Initiatives

In 2016, we found that more DOD programs were implementing WSARA acquisition reforms and "Better Buying Power" initiatives, which led to better acquisition outcomes on some programs.

In our work this year, we focused on aspects of WSARA and DOD's "Better Buying Power" initiatives that address program and portfolio affordability, cost growth controls, and the use of competition throughout the acquisition life-cycle.

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[21] GAO, *KC-46 Tanker Aircraft: Key Aerial Refueling Capabilities Should Be Demonstrated Prior to the Production Decision*, GAO-15-308 (Washington, D.C.: Apr. 9, 2015).

We found that the number of programs implementing reforms is similar or slightly less than what we have observed previously. For example, over the past year, 38 programs have conducted an affordability analysis and set affordability constraints whereas 16 have not. Also, a similar number of programs have conducted a “should-cost” analysis. These programs reported a larger total amount of realized and future expected “should-cost” savings than we observed previously, totaling $111.5 billion. This year, more programs than last year reported having no plans for competition at any point in their life cycle. Lastly, we assessed programs’ plans to complete an evaluation of potential cyber vulnerabilities by 2019.

Our analysis allows us to make the following four observations concerning key acquisition reform initiatives:

Acquisition Reform Observations

1. Of the 54 current and future programs we assessed, 38 have established an affordability constraint while 16 have not. This is similar to our prior assessment. Thus far, all but one current program that conducted an analysis and set a constraint reported they are on track to remain within their constraints.
2. Of the 45 current programs, 42 conducted a “should-cost” analysis, and 41 of those reported anticipated savings of $111.5 billion; $23.6 billion of these savings have been realized to date. Programs we assessed were unable to account for the recipient of roughly half, or $11 billion, of the realized savings that they reported.
3. Current programs are conducting competitive prototyping at a higher rate than future programs plan to do. Further, of the 54 current and future programs we assessed, 41 plan to promote some means of competition during the acquisition cycle, while 13 have no plans for competition before or after development start.
4. Of the 45 current programs we assessed, 31 reported that they plan to complete an evaluation of potential cyber vulnerabilities by 2019.

Source: GAO analysis of DOD data. | GAO-17-333SP

1. **Of the 54 current and future programs we assessed, 38 have established an affordability constraint while 16 have not. This is similar to our prior assessment. Thus far, all but one current program that conducted an analysis and set a constraint reported they are on track to remain within their constraints.** One of the reform initiatives in DOD’s “Better Buying Power” memoranda is conducting an affordability analysis that results in setting program cost constraints. This analysis differs from program cost estimates in that the constraint serves as a program requirement to ensure that it remains cost-effective.

   In accordance with DOD Instruction 5000.02, affordability constraints are intended to force prioritization of requirements, enable cost trades, and ensure that unaffordable programs do not enter the acquisition process. When approved affordability constraints cannot be met, a program's technical requirements, schedule, and required quantities must be revisited. Failure to remain within these constraints may result in program termination.

Of the current and future programs we assessed, 38 of 54 have established an affordability constraint while 16 have not. This is a similar number of programs that had implemented affordability constraints in our last assessment.

Of the 16 programs that have not established an affordability constraint, 5 are future programs that have not completed development start at which point the constraints are put in place; 11 are current programs, 6 of which began system development before this requirement was established and one program that reported its development start as to be determined (TBD). One program, the Next Generation Operational Control System, responded that it does not currently expect to meet its affordability constraints.

While the effectiveness of these constraints has yet to be widely tested, we observed that the current programs we assessed with established affordability constraints had a lower average amount of cost growth from their initial estimates compared to programs without a constraint. Specifically, of the 45 current programs, 11 programs without a constraint saw their costs increase from initial estimates by $1.8 billion whereas the 34 programs with constraints saw their costs increase by $1.2 billion.

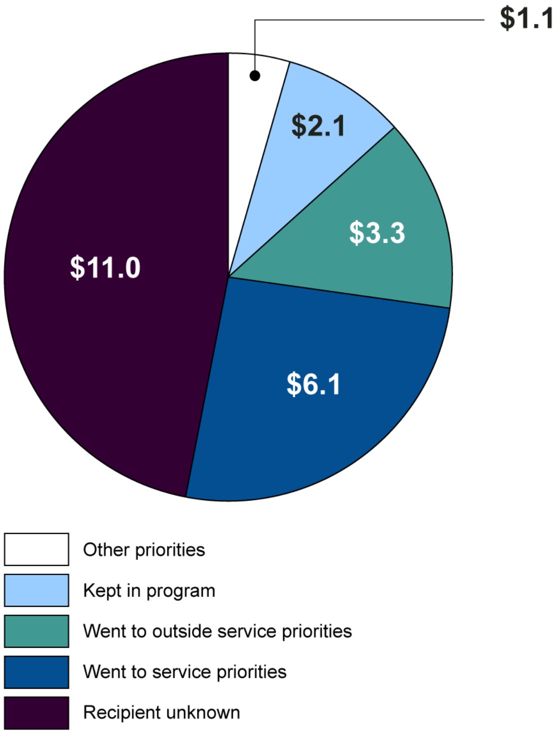
2. **Of the 45 current programs, 42 conducted a "should-cost" analysis, and 41 of those reported anticipated savings of over $111.5 billion; $23.6 billion of these savings have been realized to date. Programs we assessed were unable to account for the recipient of roughly half, or $11 billion, of the realized savings that they reported.** Stemming from DOD's "Better Buying Power" memoranda, and, in accordance with DOD Instruction 5000.02, each program must conduct a "should-cost" analysis resulting in an estimate to be used as a management tool to control and reduce cost. "Should-cost" analysis can be used to justify each cost under the program's control with the aim of reducing negotiated prices for contracts and obtaining other efficiencies in program execution to bring costs below those budgeted for the program. Any savings achieved can then be reallocated within the program or for other priorities.

   Programs can do a variety of things that could lead to "should-cost" savings including multi-year pricing, acting as a system integrator, achieving more economical productions rates, reducing overhead, and improving supply chain management, among others. The 41 programs that reported anticipated "should-cost" savings most frequently cited the following activities as responsible for some of these savings, including:

- efficiencies realized through contract negotiations (14 programs),
- design trades to balance affordability and capability (11 programs), and
- developmental or operational testing efficiencies (10 programs).

Of the current 45 programs, 28 reported $23.6 billion in realized "should-cost" savings to date. Of this amount, $4.4 billion in savings accrued from reductions in development costs, $18.9 billion from reductions in procurement costs, and $0.2 billion from reductions in military construction and acquisition-related operations and maintenance costs. Programs also provided insights as to how their realized savings have been allocated, as shown in figure 10.

Figure 10: Recipients of the $23.6 Billion in Total Realized "Should-cost" Savings (Fiscal year 2017 dollars, in billions)



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Of the $23.6 billion in realized “should-cost” savings, programs could not identify where almost half, or $11 billion, of the total savings was transferred within DOD. DOD programs may not have strong incentives to continue to identify, realize, and report “should-cost” savings if those programs do not know what the funds are being used for, or if they perceive them as resulting in the funding of other DOD priorities. Of the $12.6 billion in realized savings for which programs could identify the recipients, $2.1 billion was kept within the programs to fund other priorities. Programs reported that $178 million of savings realized were used to offset budget cuts required by sequestration. Another $6.1 billion of the realized “should-cost” savings went to priorities within the military service to which the program belongs, and $3.3 billion went to priorities outside of the service.

Current programs that we surveyed expect to realize another $87.9 billion in future “should-cost” savings. Of this amount, programs expect $1.6 billion and $15.4 billion in savings to accrue within development and procurement funds, respectively. A majority of the future expected savings was reported as acquisition-related operations and maintenance savings—totaling over $70 billion. Over $62 billion of the $70 billion was reported by the F-35 Lightning II program. In addition to the current programs, 3 of the 9 future programs reported having conducted a “should-cost” analysis and identified $7.5 billion in realized and future savings.

While most defense programs we assessed do not change their total cost estimates as a result of their “should-cost” analyses, 6 programs reported that their total cost estimate changed as a result of the savings identified, and 2 more programs are in the process of revising their cost estimate to account for their “should-cost” results.

3. **Current programs are conducting competitive prototyping prior to system development at a higher rate than future programs plan to do. Of the 54 current and future programs we assessed, 41 intend to promote competition at some point during the acquisition cycle, while 13 programs have no plans for competition before or after development start.** Competition is a critical tool for achieving the best return on the government’s investment. Major defense acquisition programs are encouraged to include in their acquisition strategies the use of prototypes from two or more contractors before a program starts system development and have acquisition strategies that ensure the option of continued competition throughout the acquisition life cycle. According to DOD, the fostering of competitive environments is a central tenet in

acquisition reform and the single best way to motivate contractors to provide the best value.

Our prior work has shown that competitive prototyping can help programs reduce technical risk, refine requirements, and validate designs and cost estimates prior to making major commitments of resources.[22] The National Defense Authorization Act for Fiscal Year 2016 revised the requirement for programs to conduct competitive prototyping and instead emphasizes prototyping as an important risk mitigation approach.[23] We have found in the past that when programs require their contractors to build prototypes for early demonstrations of capability, the product developers complete a significant amount of systems engineering which leads to valuable knowledge that better ensures that the requirements can be met within available resources.[24]

Of the 45 current programs, just under half conducted competitive prototyping. Yet, of the 9 future programs, only one identified plans to do so at the system or sub-system level before the start of system development. Programs not conducting competitive prototyping may be missing an opportunity to lower costs and reduce technical risk. Figure 11 shows how many current and future programs plan to conduct competitive prototyping.

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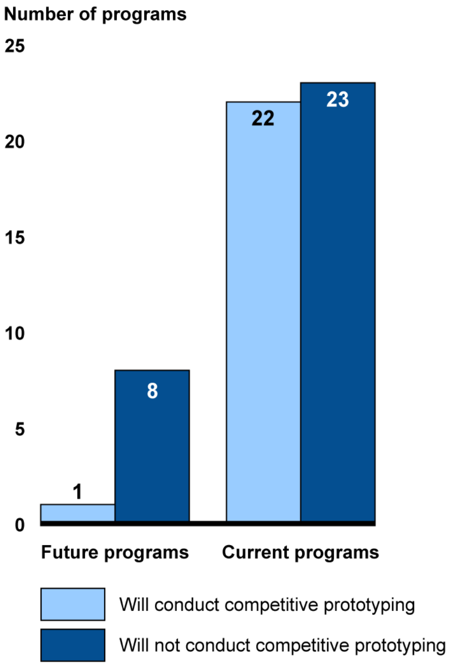
[22] GAO, *National Defense: Department of Defense's Waiver of Competitive Prototyping Requirement for the Navy's Fleet Replenishment Oiler Program*, GAO-15-57R (Washington, D.C.: Oct. 8, 2014).

[23] Pub. L. No. 114-92, § 822.

[24] GAO, *Weapon System Requirements: Detailed Systems Engineering Prior to Product Development Positions Programs for Success*, GAO-17-77 (Washington, D.C.; Nov. 17, 2016); and, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001).

Figure 11: Competitive Prototyping Plans among 54 Future and Current Programs



Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Beyond competitive prototyping, many current and future programs identified plans to undertake additional measures to promote competition. However, compared to our 2016 assessment, this year more programs reported having no plans for competition before or after development start. Thirteen programs we assessed—6 future and 7 current programs—are not planning to take, or took no actions, to promote competition either before or after their development start dates. Table 4 outlines the extent to which current and future programs are planning to promote competition and in which phases of acquisition.

Table 4: Actions Reported by 54 Current and Future Programs to Promote Competition

	For the 9 future programs	For the 45 current programs	Total
Number of programs planning to promote competition	**3**	**38**	**41**
Throughout acquisition life cycle	1	15	**16**
Only prior to the start of system development	0	7	**7**
Only after the start of system development	2	16	**18**
Number of programs taking no actions to promote competition	**6**	**7**	**13**

Source: GAO analysis of DOD data. | GAO-17-333SP

4. **Of the 45 current programs we assessed, 31 reported that they plan to complete an evaluation of potential cyber vulnerabilities by 2019.** All defense acquisition programs containing Information Technology are required to have a cybersecurity strategy that is consistent with DOD policy and standards. In addition to this strategy, the National Defense Authorization Act for Fiscal Year 2016 requires the Secretary of Defense to complete an evaluation of the cyber vulnerabilities of each major weapon system of the Department of Defense by not later than December 31, 2019.[25] In 2016, DOD reported that it is making institutional and policy changes to address cybersecurity, among other things. Specifically, according to DOD, it is ensuring that cybersecurity regulations are applied to contracts to better secure controlled information in the defense industry.

   Six programs identified completion dates after December 31, 2019. These six consist of several programs early in development, including the Three-Dimensional Expeditionary Long-Range Radar, F-15 Eagle Passive/Active Warning Survivability System, and Next Generation Jammer Increments 1 and 2. Two additional programs identified completion dates that correspond with when they expect to complete operational testing—MQ-4C Triton Unmanned Aircraft System in 2021 and VH-92A Presidential Helicopter in 2020. Another program, the LHA 6 America Class Amphibious Assault Ship, currently in

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[25] Pub. L. No. 114-92, § 1647. The requirement may be fulfilled after 2019, or waived, if the Secretary certifies to the congressional defense committees that all known cyber vulnerabilities have minimal consequences for the capability of the weapon system to meet operational requirements or otherwise satisfy mission requirements.

production and deployment, reported a date corresponding to the third ship of its class. Eight other programs did not provide dates identifying when, or if, they would complete evaluations of cyber vulnerabilities. One of these programs—the Air and Missile Defense Radar—reported that it is not scheduled to complete an evaluation.

Observations from Our Assessment of Knowledge Attained by Programs at Key Junctures

Our analysis found that although some programs are using knowledge-based practices to reduce acquisition risk, implementation continues to be inconsistent. For example, programs that recently began system development demonstrated some best practices—such as completing a system-level preliminary design review before committing resources. Others, however, are carrying technology risk well into system development, failing to demonstrate designs through prototyping, or proceeding into production before ensuring manufacturing processes are under control and developmental testing is complete.

Our body of work has shown that positive acquisition outcomes require the use of a knowledge-based approach to product development that demonstrates high levels of knowledge attained before significant commitments are made.[26] In essence, knowledge supplants risk over time. This work led to multiple recommendations that DOD has generally or partially agreed with and has made progress in implementing. On the basis of this work, we identified three key knowledge or decision points during the acquisition cycle—development start, system-level critical design review, and production start—at which programs need to demonstrate critical levels of knowledge to proceed. Figure 12 aligns the acquisition milestones described in DOD's primary acquisition policy with these key decision points.

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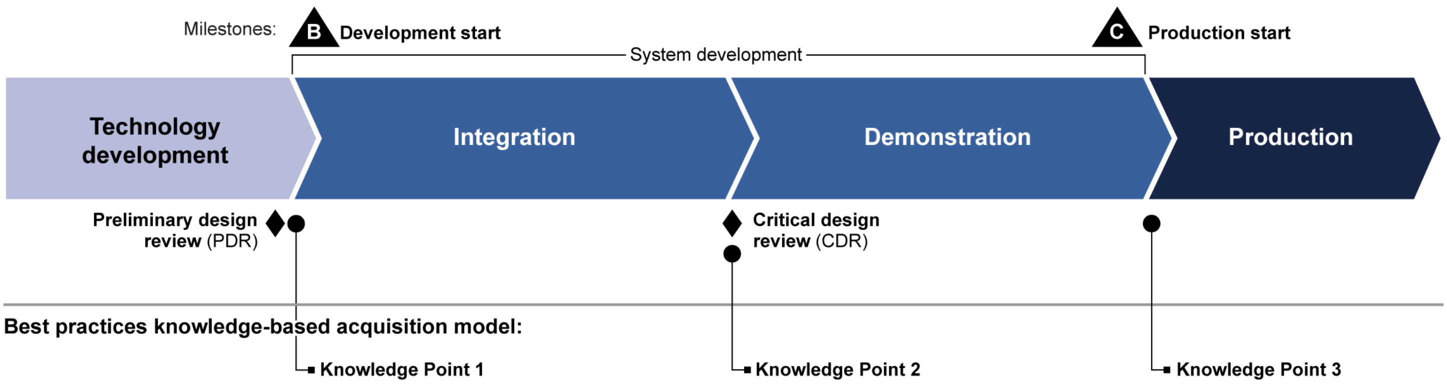
[26] GAO, *Best Practices: DOD Can Achieve Better Outcomes by Standardizing the Way Manufacturing Risks Are Managed*, GAO-10-439 (Washington, D.C.: Apr. 22, 2010); *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002); *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Figure 12: Defense Acquisition Cycle and GAO Knowledge Points

Department of Defense (DOD) acquisition process:



Best practices knowledge-based acquisition model:

Knowledge Point 1

Technologies, time, funding and other resources match customer needs.

Decisions to invest in product development.

Key steps:

- PDR completed
- Technologies demonstrated to high levels
- Incremental acquisition strategy in place
- Knowledge-based cost estimate

Knowledge Point 2

Design is stable and performs as expected.

Decisions to start building and testing production representative prototypes.

Key steps:

- Subsystems and system level CDRs completed
- Ninety percent of engineering drawings released
- Early integrated system prototype demonstrated
- Critical manufacturing process identified

Knowledge Point 3

Production meets cost, schedule, and quality target.

Decisions to produce first units for customer.

Key steps:

- Fully integrated, capable prototype demonstrated in intended environment.
- Manufacturing processes in control
- Product reliability demonstrated

Source: GAO analysis of DOD provided data, DOD Instruction 5000.02, and best practices. | GAO-17-333SP

As our prior work has shown, the building of knowledge consists of information that should be gathered at these three critical points over the course of a program.

Knowledge point 1: Resources and requirements match. Achieving a high level of technology maturity by the start of system development is one of several important indicators of whether this match has been made. This means that the technologies needed to meet essential product requirements should be form, fit, and function, integrated with other key supporting elements and have been demonstrated to work in a realistic environment. In addition, the developer should complete a series of systems engineering reviews culminating in a preliminary design of the product that shows the design is feasible. Constraining the development phase of a program to 5 or 6 years is also recommended because it aligns with DOD’s budget planning process and fosters the negotiation of trade-offs in requirements and technologies. For shipbuilding programs, critical technologies should be matured into actual sub-system prototypes and successfully demonstrated in an operational environment before a contract is awarded for the detail design of a new ship.

Knowledge point 2: Product design is stable. This point occurs when a program determines that a product’s design will meet customer requirements as well as cost, schedule, and reliability targets. A best practice is to achieve design stability at the system-level critical design review, usually held midway through system development. Completion of at least 90 percent of engineering drawings at this point provides tangible evidence that the product’s design is stable, and a prototype demonstration shows that the design is capable of meeting performance requirements. Shipbuilding programs should demonstrate design stability by completing 100 percent of the basic and functional drawings, generally corresponding to a three-dimensional product model, by the start of construction for a new ship. Programs can also improve the stability of their designs by conducting reliability growth testing and completing failure modes and effects analyses so fixes can be incorporated before production begins. At this point, programs should also begin preparing for production by identifying manufacturing risks, key product characteristics, and critical manufacturing processes.

Knowledge point 3: Manufacturing processes are mature. This point is achieved when it has been demonstrated that the developer can manufacture the product within cost, schedule, and quality targets. A best practice is to ensure that all critical manufacturing processes are in statistical control—that is, they are repeatable, sustainable, and capable of consistently producing parts within the product’s quality tolerances and standards—at the start of production. Demonstrating critical processes on a pilot production line is an important initial step in this effort. In addition, production and post-production costs are minimized when a fully integrated, capable production-representative prototype is demonstrated to show that the system will work as intended in a reliable manner before committing to production. We did not assess shipbuilding programs for this knowledge point due to differences in the production processes used to construct ships.

Knowledge in these three areas builds over time. Our prior work on knowledge-based approaches shows that a knowledge deficit early in a program can cascade through design and production, leaving decision makers with less knowledge to support decisions about when and how to best move into subsequent acquisition phases that commit more budgetary resources. Demonstrating technology maturity is a prerequisite for moving forward into system development, during which time the focus should be on design and integration. A stable and mature design is also a prerequisite for moving forward into production, where the focus should be on efficient manufacturing. Additional details about key practices at each of the knowledge points can be found in appendix IV.

For this report, we assessed the knowledge attained at key junctures in the acquisition process for 45 current programs, which are mostly in development or early production.[27] Not all programs included in our review of knowledge-based practices provided information for every knowledge point and some had not reached all of the knowledge points—development start, design review, and production start—at the time of this assessment. We also reviewed the knowledge that 9 future major defense acquisition programs, as identified by DOD, expect to attain when they start system development in the coming years.[28] In addition, we analyzed the extent to which programs are undertaking concurrent developmental testing and production as well as their software development efforts to determine how they monitor and manage them.

Our analysis of the data from these current and future programs allows us to make the following five observations.

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[27] Because knowledge points and best practices differ for shipbuilding programs, we exclude the six shipbuilding programs in DOD's portfolio from parts of our analysis at each of the three knowledge points. For more information, see appendix I.

[28] Information for these programs was collected from two data collection instruments distributed to program officials. See the "Analysis of Selected DOD Programs Using Knowledge-Based Criteria and Program Concurrency" section of appendix I for more information.

Knowledge Point and Program Concurrency Observations

1. Of the four programs that began or planned to begin system development during our assessment period, only one has demonstrated a total match between resources and requirements. One program plans to enter system development with immature technologies, one will have technologies approaching maturity, and two programs have not identified critical technologies to evaluate. Three of the programs completed a preliminary design review before development start. Two did not conduct all of the early system engineering reviews recommended by best practices. Two of four programs plan to constrain their development to less than 6 years.
2. Of the four programs that held or planned to hold a critical design review during our assessment period, none met all of the best practices. One of the programs has demonstrated mature technologies. While all programs plan to release at least 90 percent of drawings, three also do not plan to test a system-level integrated prototype. The implementation of best practices by these programs has degraded almost 40 percent from what we observed in 2016.
3. Of the three programs that held or planned to hold a production decision during our assessment period, none met all of the best practices. Two programs did not test a production-representative prototype before making a production decision, and only one of the three demonstrated processes on a pilot production line. The implementation of best practices at this juncture was mixed or slightly degraded compared to DOD programs' past implementation.
4. Eighteen programs in production plan to complete 30 percent or more of their developmental testing concurrent with production. Nine of these 18 programs plan to place more than 20 percent of their procurement quantities under contract before testing is complete.
5. Of the 54 current and future programs we assessed, 41 reported software development as a high-risk area. Despite this, almost half of the current programs do not separately price or track the cost of the software development efforts. Of the 45 current programs we assessed, 11 programs plan to start production prior to completing software development.

Source: GAO analysis of DOD data. | GAO-17-333SP

1. **Of the four programs that began or planned to begin system development during our assessment period, only one has demonstrated a total match between resources and requirements. One program plans to enter system development with immature technologies, one will have technologies approaching maturity, and two programs have not identified critical technologies to evaluate. Three of the programs completed a preliminary design review before development start. Two did not conduct all of the early system engineering reviews recommended by best practices. Two of four programs plan to constrain their development to less than 6 years.** Our prior work shows that the most critical juncture in any major defense acquisition is the decision to start system development, a point at which knowledge-based acquisition practices recommend having a match between what DOD wants in a weapon system, as defined by its requirements, and the mature technologies, funding, schedule, and

other resources needed to develop that system.[29] Figure 13 shows the extent to which DOD has implemented recommended acquisition practices for knowledge point 1 for the four programs that recently started system development or plan to do so in early 2017: F-15 Eagle Passive/Active Warning and Survivability System (F-15 EPAWSS), Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc 2-I Block 1), the Columbia Class Ballistic Missile Submarine (Columbia Class SSBN) (formerly the Ohio Class Replacement), and the Presidential Aircraft Recapitalization (PAR)—as well as the other 41 current programs we assessed that previously accomplished this knowledge point.

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[29] GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

Figure 13: Implementation of Knowledge-Based Practices for Programs in System Development

Knowledge-based practices at system development start	Columbia Class SSBN	F-15 EPAWSS	IFPC Inc 2-I Block 1	PAR	Other 41 programs		
					●	○	——
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment (TRL 6)	○	●	——	——	23	11	7
Demonstrate all critical technologies are in form, fit, and function within an operational environment (TRL 7)	○	○	——	——	3	29	9
Complete system functional review and system requirements review before system development start	○	●	●	○	15	25	1
Completed preliminary design review before system development start	●	●	●	○	19	21	1
Constrain system development phase to 6 years or less	——	●	●	——	27	6	8

● Practice implemented

○ Practice not implemented

——— Practice not applicable or information not available per the program office response

Columbia Class SSBN = Columbia Class Ballistic Missile Submarine
F-15 EPAWSS = F-15 Eagle Passive/Active Warning Survivability System
IFPC Inc 2-I Block 1= Indirect Fire Protection Capability Increment 2-Intercept Block 1
PAR = Presidential Aircraft Recapitalization

Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Demonstrate Technology Maturity

We assessed whether programs starting system development met two different best practices for technology maturity. First, federal statute requires that programs generally obtain a certification stating that technologies have been demonstrated within a relevant environment which as implemented means being very close to final form, fit, and function.[30] Second, knowledge-based acquisition practices recommend that programs fully mature technologies and demonstrate them in an operational—or realistic—environment prior to starting system development. This is a higher level of technology maturity than required by law. Demonstrating technologies in an operational environment is a better indicator of whether a program has achieved a resource and requirements match, as it demonstrates the technologies' form, fit, and function as well as the effect of the intended environment on those technologies.

One program—the Columbia Class SSBN—does not plan to demonstrate all of its critical technologies in a relevant environment at the statutorily required level and has obtained a waiver to do so. Columbia Class SSBN is a program that will replace the Navy's current fleet of Ohio-class ballistic missile submarines. The program began system development in January 2017 and has identified two critical technologies. The Navy has subsequently determined that one is no longer a critical technology based on testing in a relevant environment. The other technology was assessed to be immature, but the program was granted a waiver from meeting this requirement. To mitigate the development risk, the Navy plans to share parts and components with the Virginia-class submarine, to the extent possible.

We also found that, of the four programs that began or were planning to begin system development in 2016, two programs had not fully matured their technologies and the other two did not identify any critical technologies. Fully mature technologies are defined as those that have been demonstrated in their final form, fit, and function within an operational environment with a prototype.

An independent review team, led by the Air Force Life Cycle Management Center determined that the F-15 EPAWSS program's technologies were approaching maturity at the start of system development, but were not fully mature by best practices. The program does not plan on attaining full maturity until after its

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[30] Demonstration in a relevant environment is Technology Readiness Level (TRL) 6. Demonstration in an operational environment is TRL 7. See appendix V for detailed descriptions of TRLs. In addition, a major defense acquisition program generally may not receive approval for development start until the milestone decision authority certifies that the technology in the program has been demonstrated in a relevant environment. 10 U.S.C. § 2366b(a)(3)(D). Under certain circumstances, this requirement may be waived.

scheduled critical design review in March 2017. This delay leaves it at risk for flight test delays if the technologies do not mature as planned. The Army conducted a Technology Readiness Assessment for the IFPC Inc 2-I Block 1 program that identified no critical technologies at the start of its system development. This is due to the maturity of the program's sub-systems, which have already been fielded or are in production. Since IFPC Inc 2-I Block 1 and the PAR programs do not have critical technologies, we did not evaluate them for this best practice. The Columbia Class SSBN technologies are immature as the program begins system development, as the Navy has not demonstrated all technologies in an operational environment. As our prior work on shipbuilding best practices has shown, this strategy introduces risk for cost and schedule growth in the program.[31]

Of the remaining 41 programs, just 3 reported that all of their critical technologies were mature to best practices—in other words, demonstrated in an operational environment—when they began development, while 23 programs reported that their technologies were nearing maturity. Among all programs in our assessment, just 7 percent began system development with fully mature technologies.

DOD acquisition reforms included in WSARA and DOD's "Better Buying Power" initiatives are intended to improve acquisition procedures. We examined whether programs started before or after the implementation of these initiatives met the best practice to have mature technologies and their subsequent levels of cost growth. To do so, we assessed (1) whether the 45 programs started development before or after implementation of WSARA; (2) what their level of technology maturity was at that time; and (3) their development cost growth. Of the 45 programs, 19 were started before the implementation of WSARA, 25 were started after, and one did not have a system development start. Nine of the 19 programs that started before the implementation of WSARA began development with immature technologies. These 9 programs include 3 shipbuilding programs— CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier, DDG 1000 Zumwalt Class Destroyer, and Littoral Combat Ship—as well as the CH-53K Heavy Lift Replacement Helicopter, the F-35 Lightning II, Joint Tactical Radio System Handheld, Manpack, and

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[31] GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

Small Form Fit Radios, Littoral Combat Ship Mission Modules, Patriot Advanced Capability-3 Missile Segment Enhancement, and the Warfighter Information Network-Tactical Increment 2 programs. These programs met almost none of the development start best practices recommended in our body of work. Since they began system development, as a group they have realized almost $35 billion in development cost growth. In contrast, 5 of the programs that started before implementation of WSARA began development with nearly mature or fully mature technologies and have realized $1.6 billion in development cost growth, a significant difference from that of the programs with immature technologies at development start. The remaining 5 programs did not report on the technology maturity at this point. This is a limited set of programs to analyze, but we have observed that those using fewer best practices realized significantly more cost growth. As a result, we believe that programs implementing more of the best practices in the future will continue to realize less cost growth.

Complete Systems Engineering Reviews before Development Start

Knowledge-based acquisition practices recommend that programs hold systems engineering events, including a system requirements review and a system functional review, before the start of system development:

- System requirements reviews ensure that requirements have been properly identified and that there is a mutual understanding between the government and the contractor.
- System functional reviews establish a baseline for the planned system.

We found that 2 programs completed these reviews prior to starting system development and 2 did not. The Columbia Class SSBN program held a system requirements review, but not the system functional review. The PAR program held neither review.

Regarding the use of this best practice on the other 41 programs we assessed, 37 percent held both reviews before system development start and 61 percent held neither or only one of these reviews before starting system development. This implementation rate is similar to last year, in which 37 percent of the programs we reviewed held both reviews before development and 60 percent held neither.

Complete Preliminary Design Review before System Development Start

In addition to the engineering reviews, knowledge-based acquisition practices recommend the completion of a preliminary design review, before the start of system development to ensure that requirements are defined and feasible, and that the proposed design can meet those requirements within cost, schedule, and other system constraints. At preliminary design review is when a program should have completed sufficient systems engineering so as to establish an "allocated baseline"—essentially, definition of all subsystems and how they are to work together.

In a November 2016 report, we found that establishing a preliminary design through early detailed systems engineering portends better program outcomes than doing so after program start.[32] WSARA emphasized the value of defining an allocated baseline early by establishing a statutory requirement to conduct a preliminary design review prior to starting a development program or obtain a waiver to the requirement.[33] Among the 4 programs that started system development during our assessment period, all but one of them conducted this review before beginning system development. PAR obtained a waiver to this requirement and plans to hold its preliminary design review in April 2018, over a year and a half after its development start. Nineteen of the other 41 programs held a preliminary design review before the start of system development. Sixty-eight percent of programs that began development since the implementation of WSARA are implementing this practice compared to 26 percent of programs that began development before the implementation of WSARA, which is an improvement from last year's assessment.

Begin Future Programs with Adequate Knowledge

As part of our analysis, we assessed 9 future programs scheduled to become major defense acquisition programs in coming years. These

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[32] GAO, *Weapon System Requirements: Detailed Systems Engineering Prior to Product Development Positions Programs for Success*, GAO-17-77 (Washington, D.C.: Nov. 17, 2016).

[33] Pub. L. No. 111-23, § 205(a). A major defense acquisition program may not receive milestone B approval until the program has held a preliminary design review and the milestone decision authority has conducted a formal post-preliminary design review assessment and certified on the basis of such assessment that the program demonstrates a high likelihood of accomplishing its intended mission unless a waiver is properly granted by the milestone decision authority. 10 U.S.C. § 2366b(a)(2), (d)(1).

programs provided information on the knowledge they planned to obtain and the best practices they intend to implement before their system development start is approved. Four identified critical technologies, 2 of which identified their anticipated maturity levels expected at system development start. One future program—the T-AO 205 John Lewis Class Fleet Oiler (formerly T-AO(X))—reported its critical technologies as fully mature in October 2014, almost 3 years before its planned development start. Two of the future programs reported that their critical technologies are expected to be nearing maturity and the remaining program reported that its critical technology maturity has not yet been determined for the time of their system development start.

Unlike the programs that held system development start in the past year, only 2 of the 9 future programs plan to hold a preliminary design review before the start of system development and only 3 programs plan to conduct both a system functional and system requirements review before that time. While all but one of the future programs currently plan to limit their system development phase to 6 years or less, these plans are preliminary and the programs are at risk of not satisfying all the knowledge-based practices we reviewed, leaving them at risk for cost and schedule growth, as table 5 indicates. The remaining programs reported that their critical technologies would not be fully mature or have not been identified. One program's technology maturity will be determined at system development start.

Table 5: Projected Implementation of Knowledge-Based Practices for Future Programs

	Development start	Projected to demonstrate all critical technologies in an operational environment	Projected to complete all systems engineering reviews	Plan to constrain system development
Long Range Precision Fires	TBD	—-	O	●
T-AO 205 John Lewis Class Fleet Oiler	06/2017	●	●	●
P-8A Poseidon Multi-Mission Maritime Aircraft Increment 3	NA	—-	O	—-
MQ-25 Stingray Unmanned Air System	05/2018	—-	O	●
Joint Surveillance Target Attack Radar System Recapitalization	10/2017	—-	O	●
Improved Turbine Engine Program	TBD	O	O	●
Amphibious Ship Replacement	TBD[a]	—-	O	●
Advanced Pilot Training	12/2017	—-	O	●

	Development start	Projected to demonstrate all critical technologies in an operational environment	Projected to complete all systems engineering reviews	Plan to constrain system development
Weather Satellite Follow-On	06/2018	O	●	●

● Implementation planned

O No implementation planned

—- Practice to be determined

Source: GAO analysis of DOD data. | GAO-17-333SP

Note: We assessed the P-8A Poseidon Multi-Mission Maritime Aircraft Increment 3 as part of the 9 future major defense acquisition programs not yet in the portfolio. During the course of our review, we learned that DOD no longer plans to manage Increment 3 separately from the existing P-8A program. We will reflect this change in future assessments of the P-8A program.

[a] The Amphibious Ship Replacement is by-passing system development and entering the DOD acquisition process in the production phase at a point which is to be determined.

Enforcing discipline and accountability at the start of development are essential for establishing satisfactory acquisition outcomes. Top decision makers need to ensure that programs will meet a knowledge-based approach before the programs are approved and funded. However, our observations show that the future programs plan to proceed without meeting these best practices which creates an environment where they are not held to DOD’s standard, which makes successful acquisition outcomes unlikely.

2. **Of the four programs that held or are planning to hold a critical design review during our assessment period, none met all of the best practices. One of the programs has demonstrated mature technologies. While all programs plan to release at least 90 percent of drawings, three also do not plan to test a system-level integrated prototype. The implementation of best practices by these programs has degraded almost 40 percent from what we observed in 2016.** For this key milestone in a program’s acquisition, we assessed eight best practices to determine the extent to which programs are attaining the knowledge needed for a low-risk acquisition. We have previously reported that programs that hold their critical design review before achieving knowledge of a stable demonstrated design also experience higher average costs and longer schedule delays. Figure 14 shows the extent to which recommended acquisition practices for knowledge point 2 have been implemented for the four programs that recently finished their critical design review, or plan to in early 2017: Armored Multi-Purpose Vehicle (AMPV), Common Infrared Countermeasure (CIRCM), Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1), VH-92A

Presidential Helicopter Replacement Program (VH-92A)—as well as the other 31 current programs we assessed, which previously accomplished this knowledge point.

Figure 14: Implementation of Knowledge-Based Practices for Selected Programs at Critical Design Review

Knowledge-based practices at critical design review	AMPV	CIRCM	OASuW Inc 1	VH-92A	Other 31 programs		
					●	○	——
Demonstrate all critical technologies in an operational environment	●	○	○	——	6	19	6
Release at least 90 percent of drawings	●	●	●	●	10	16	5
Test an early system-level integrated prototype	○	●	○	○	5	19	7
Establish a reliability growth curve	●	●	——	●	21	6	4
Identify key product characteristics	●	——	●	●	27	0	4
Identify critical manufacturing processes	●	——	●	●	25	1	5
Conduct producibility assessments to identify manufacturing risks for key technologies	●	——	●	——	24	2	5
Complete failure modes and effects analysis	●	●	●	●	24	1	6

● Practice implemented

○ Practice not implemented

——— Practice not applicable or information not available per the program office response

AMPV = Armored Multi-Purpose Vehicle
CIRCM = Common Infrared Countermeasure
OASuW Inc 1 = Offensive Anti-Surface Warfare Increment 1
VH-92A = VH-92A Presidential Helicopter Replacement Program

Source: GAO analysis of Department of Defense data. | GAO-17-333SP

Demonstrate Technology Maturity

As product knowledge is cumulative, by the critical design review, programs should have demonstrated critical technologies in an operational environment to ensure that the product can meet requirements. Failure to fully mature technologies prior to developing the system design can lead to redesign and cost and schedule growth if later discoveries during development lead to revisions. Of all the knowledge-based acquisition practices programs strive to implement throughout the acquisition life cycle, this is one of the least utilized.

The OASuW Inc 1 program does not plan to meet this best practice before completing its critical design review. This program has six critical technologies; five are immature and one is approaching maturity, but none will be demonstrated in an operational environment at the time of the program's critical design review. Additionally, the CIRCM program identified seven critical technologies, which were not mature at the program's critical design review. The AMPV program is the only program with mature technologies that held a critical design review this year. The VH-92A program did not identify critical technologies at this juncture; therefore, we did not evaluate it for that practice.

To assess the effect of technology maturity on cost over time, we also examined the 19 programs that started development 7 or more years ago and the level of their technology maturity at the time of their critical design review. We found that of these 19 programs, 6 held their critical design review with immature technologies. These 6 programs have realized over $33 billion, or 63 percent, in development cost growth over their initial cost estimates. These include the same three shipbuilding programs mentioned in the previous section—CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier, Littoral Combat Ship, and DDG 1000 Zumwalt Class Destroyer—which started system development with immature technologies. They also include the F-35 Lightning II, M109A7 Family of Vehicles, and Patriot Advanced Capability-3 Missile Segment Enhancement programs. In contrast, 8 programs had fully mature technologies or nearly mature technologies at their critical design review. These 8 programs realized $4.7 billion, or 31 percent, in development cost growth, which is significantly less than the programs with immature technologies.

Demonstrate System Design Stability

All of the programs holding their critical design review in 2016 demonstrated design stability by releasing over 90 percent of their expected design drawings. This is an encouraging development, as it represents the second year in a row in which all programs being evaluated met this best practice. Out of the other 31 programs that previously held their design reviews, 10 met this best practice and 16 did not. For the 5 remaining programs, the program offices reported this practice was not applicable.

Testing of an early prototype is useful for demonstrating that a system will work as intended and can be built within cost and schedule. Only

1 of the 4 programs—CIRCM—tested a system-level integrated prototype prior to its critical design review. This is a decline since last year's review, when only 2 of the 5 programs we evaluated did not test a system-level prototype before their design review.

One program that did not test a system-level integrated prototype is the VH-92A program, which is developing a helicopter for transporting the President, Vice President, heads of state, and other dignitaries. The program entered system development in 2014 and conducted its design review in July 2016. VH-92A does not have any critical technologies, and it plans to reduce risk by utilizing a commercial aircraft and mature technologies, which are already in use. The program demonstrated some design stability by completing all of its design drawings, but it did not test a system-level integrated prototype. Instead, it plans to verify its design by testing a fully configured, production-level prototype in 2018. Additionally, while both the AMPV and OASuW Inc 1 programs demonstrated some design stability by releasing more than 90 percent of their design drawings, neither tested a system-level prototype before critical design review. The AMPV is a derivative vehicle utilizing mature technologies and sub-systems and the program's acquisition strategy did not allow time to develop and test an early system-level prototype. AMPV plans to test a system-level prototype in the future. OASuW Inc 1 plans to test its system-level prototype in March 2017.

We assessed 31 other programs that held a critical design review prior to 2016, and found that only 5 tested an early integrated prototype before critical design review. We did not assess shipbuilding programs against this knowledge-based acquisition practice as testing early system-level prototypes in these programs may sometimes be impractical, particularly in instances when these programs are not delivering large quantities. The limited use of this testing before design review among the programs we assessed shows no improvement from our prior assessments. Of all the knowledge-based acquisition practices programs strive to implement throughout the acquisition life cycle, this is the least utilized at this juncture. Without demonstrating at this point that the system can work as intended, the risk that the program will face design changes and schedule delays later in the acquisition cycle increases.

Remaining Critical Design Review Best Practices

Of the 4 programs we assessed only the AMPV plans to implement the last five knowledge-based practices shown in figure 14 to increase confidence in the stability of the product's design and its effect on production. This includes establishing a reliability growth curve, identifying key product characteristics, identifying critical manufacturing processes, conducting producibility assessments, and completing a failure mode and effects analysis. The exceptions come from three programs that are not implementing one or more of these practices and instead report the practices are not applicable for various reasons, which include limited production quantities and lack of identified critical technologies. For the other 31 programs in this assessment that have already held their critical design review, a majority of them reported using each of these practices.

3. **Of the three programs that held a production decision during our assessment period, none met all of the best practices. Two programs did not test a production-representative prototype before making a production decision, and only one program demonstrated processes on a pilot production line. The implementation of best practices at this juncture was mixed or slightly degraded compared to DOD programs' past implementation.** Capturing critical manufacturing knowledge before entering production ensures that a weapon system will work as intended and can be manufactured efficiently to meet cost, schedule, and quality targets. This knowledge can be captured through the use of various proactive methods, including the use of statistical process control data, pilot production lines, manufacturing readiness levels, and prototype testing. There are three programs that held a production decision during our assessment period-the F-22 Increment 3.2B Modernization (F-22 Inc 3.2B), the KC-46A Tanker Modernization (KC-46A), and the Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1). Figure 15 shows the extent to which these programs have implemented the associated knowledge-based practices.

Figure 15: Implementation of Knowledge-Based Practices for Selected Programs at Production Decision

Knowledge-based practices at production start	F-22 Inc 3.2 B	KC-46A	OASuW Inc 1	For the 15 non-shipbuilding programs that have reached this juncture[b]		
				●	○	——
Demonstrate all critical technologies in an operational environment	●	●	●	9	3	3
Release at least 90 percent of drawings	●	●	●	7	4	4
Demonstrate manufacturing process capabilities are in control	○	○	○	1	11	3
Demonstrate critical processes on a pilot production line	○	●	——	8	4	3
Test a production-representative prototype in its intended environment	○	●	○	6	7	2

● Practice implemented

○ Practice not implemented

——— Practice not applicable or information not available per the program office response

F-22 Inc 3.2B = F-22 Increment 3.2B Modernization
KC-46A = KC-46A Tanker Modernization Program
OASuW Inc 1 = Offensive Anti-Surface Warfare Increment 1

Source: GAO analysis of Department of Defense data. | GAO-17-333SP

[b] We have excluded shipbuilding programs from this analysis due to differences in the production processes used to construct ships.

Demonstrate Manufacturing Process Capabilities Are in Control

None of the programs that held recent production decisions demonstrated that their manufacturing process capabilities were in control. Our prior work has shown that capturing critical manufacturing knowledge before entering production helps ensure that the system will work as intended and will meet cost, schedule, and quality targets. Of the remaining 15 non-shipbuilding programs we assessed, which held production decisions before our current assessment period, one provided data indicating that critical manufacturing processes were in control at the time of their production start. Of all the knowledge-based acquisition practices described, this is the least utilized at this juncture.

Demonstrate Critical Processes on a Pilot Production Line

One of the programs that held a production decision over the past year demonstrated critical processes on a pilot production line. This is a fair decline from what we observed last year, when all 5 of the programs we reviewed met this knowledge practice. Of the 21 programs we assessed that plan to hold a production decision in the future, 11 indicated that they intended to test a pilot production line before production start. Of the remaining 15 non-shipbuilding programs, 8 have demonstrated this best practice whereas 4 did not.

Test a Production-representative Prototype in Its Intended Environment

Our body of work has shown that production and post-production costs are also minimized when a fully integrated, production-representative prototype is demonstrated prior to the production decision, as making design changes after production begins can be both costly and inefficient. The KC-46A plans to meet this best practice, but the F-22 Inc 3.2B and OASuW Inc 1 do not plan to complete this testing until approximately 4 months and 1 year, respectively, after their production decision dates. Additionally, 16 of the programs we assessed that plan to hold their production decision in the future intend to test a fully configured prototype. Programs that do not conduct testing of production-representative prototypes prior to beginning manufacturing risk discovering deficiencies late in testing, which may trigger the need for expensive re-tooling of production lines and retrofitting of articles that have completed production. Of the other 15 non-shipbuilding programs we assessed, 6 reported testing a production-representative prototype before this decision.

4. **Eighteen programs in production plan to complete 30 percent or more of their developmental testing concurrent with production. Nine of these 18 programs plan to place 20 percent or more of their procurement quantities under contract before testing is complete.** Conducting developmental testing while in production increases the risk of finding problems that could lead to design changes and costly retrofits. Developmental testing is intended to demonstrate that a chosen design has the capabilities required and to discover and fix problems before a system enters production. Though DOD policy allows some degree of concurrency between initial production and developmental testing, beginning production before demonstrating that a system will work as intended increases the risk of deficiencies that require substantial design changes and costly modifications to already-produced systems.

   Eighteen of the programs we assessed plan to complete a significant portion of their testing—30 percent or more—after they have already started production. Further, 9 of these programs also plan to put 20 percent or more of their procurement quantities under contract before the testing in complete. These programs are the DDG 1000 Zumwalt Class Destroyer, F-22 Increment 3.2B Modernization, Global Positioning System III, LHA 6 America Class Amphibious Assault Ship, M109A7 Family of Vehicles, MQ-8 Fire Scout Unmanned Aircraft System, Offensive Anti-Surface Warfare Increment 1, F-35 Lightning II, and the Family of Advanced Beyond Line-of-Sight Terminals. Concurrency is also justified to expedite the development of an accelerated acquisition program. However, concurrently developing and producing high cost systems without knowing whether their capabilities can be demonstrated is a high-risk strategy.

5. **Of the 54 current and future programs we assessed, 41 reported software development as a high-risk area. Despite this, almost half of the current programs do not separately price or track the cost of the software development efforts. Of the 45 current programs we assessed 11 plan to start production prior to completing software development.** Software development has similar phases to that of hardware and—in the case of new systems—occurs in parallel with hardware development until software and hardware components are integrated. According to DOD policy, major contracts and subcontracts for contractors developing or producing software elements for major defense acquisition programs are required to submit a report, which includes software resources if the effort is projected to be greater than $20 million.[34] Half of the programs we assessed do not track the cost of their software development, citing a variety of reasons. For example, several programs reported that the software is embedded into the overall system development and would be difficult to extract.

   Nonetheless, of the 45 current programs we surveyed, 35 indicated that they had identified software development as a high-risk area, similar to the number of programs that reported this in 2016. Of the 9 future programs, 6 identified their software development as high risk.

   Programs report a variety of reasons that lead to characterizing their software development effort as high risk. Common reasons include:

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[34] Specifically, all major contracts and subcontracts, regardless of contract type, for contractors developing or producing software elements within MDAP and pre-MDAP programs, as well as other certain acquisitions, such as those of certain automated information systems, for any software development element with a projected software effort greater than $20 million (then-year dollars) are required to complete a Software Resources Data Report. DOD Instruction 5000.02.

- Completion of the originally planned software effort has proved to be more difficult than expected (27 programs),
- Completion of the software effort needed to conduct developmental testing successfully (30 programs),
- Changes to meet cyber security needs led to additional software development efforts (25 programs), and
- Completion of the software effort to conduct operational testing successfully (21 programs).

Of the 35 programs identifying software development as high risk, 26 percent are not tracking their software costs. Programs not tracking software costs limit the information managers and decision makers have, making it difficult to manage and oversee these programs. DOD Instruction 5000.02 provides programs several types of acquisition models from which to choose. Two of the 54 programs in our assessment reported using the defense unique software intensive program model, and 3 identified themselves as “hybrid program—software dominant.” A majority of programs estimated that between 0 to 20 percent of their total acquisition cost is for software.

Eleven of the 45 current programs we assessed plan to begin production prior to completing the software development necessary for integration with system hardware and achieving baseline capabilities. DOD policy allows for some degree of concurrency between initial production and the completion of developmental testing, especially for the completion of software. While some concurrency may be necessary when rapidly fielding urgently needed capabilities, pursuing software development while the system is in production may introduce risks if problems are discovered late in testing.

Assessments of Individual Programs

This section contains assessments of individual weapon programs grouped by lead service—Army, Navy and Marine Corps, Air Force, and DOD-led—and includes a lead service separator page at the start of each grouping. Each assessment presents data on the extent to which programs are following a knowledge-based acquisition approach to product development, and other program information. Each lead service separator page summarizes information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained. In total, we present information on 54 programs.[35]

For 43 programs, we produced two-page assessments discussing the technology, design, and manufacturing knowledge obtained, as well as other program issues. Each two-page assessment also contains a comparison of total acquisition cost from the first full estimate for the program to the current estimate. The first full estimate is generally the cost estimate established at development start; however, for a few programs that did not have such an estimate, we used the estimate at production start instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For programs that began as non-major defense acquisition programs, we used the first full estimate available. All of these 43 two-page assessments are of major defense acquisition programs, most of which are in development or early production and 3 assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. See figure 16 for an illustration of the layout of each two-page assessment.

In addition, we produced one-page assessments on the current status of 11 programs, which include 9 future major defense acquisition programs and 2 major defense acquisition programs that are well into production, but are developing new increments of capability as part of their existing programs. We also produced a one-page assessment of the Navy’s Frigate initiative, which DOD has not yet formally identified as a future major defense acquisition program.

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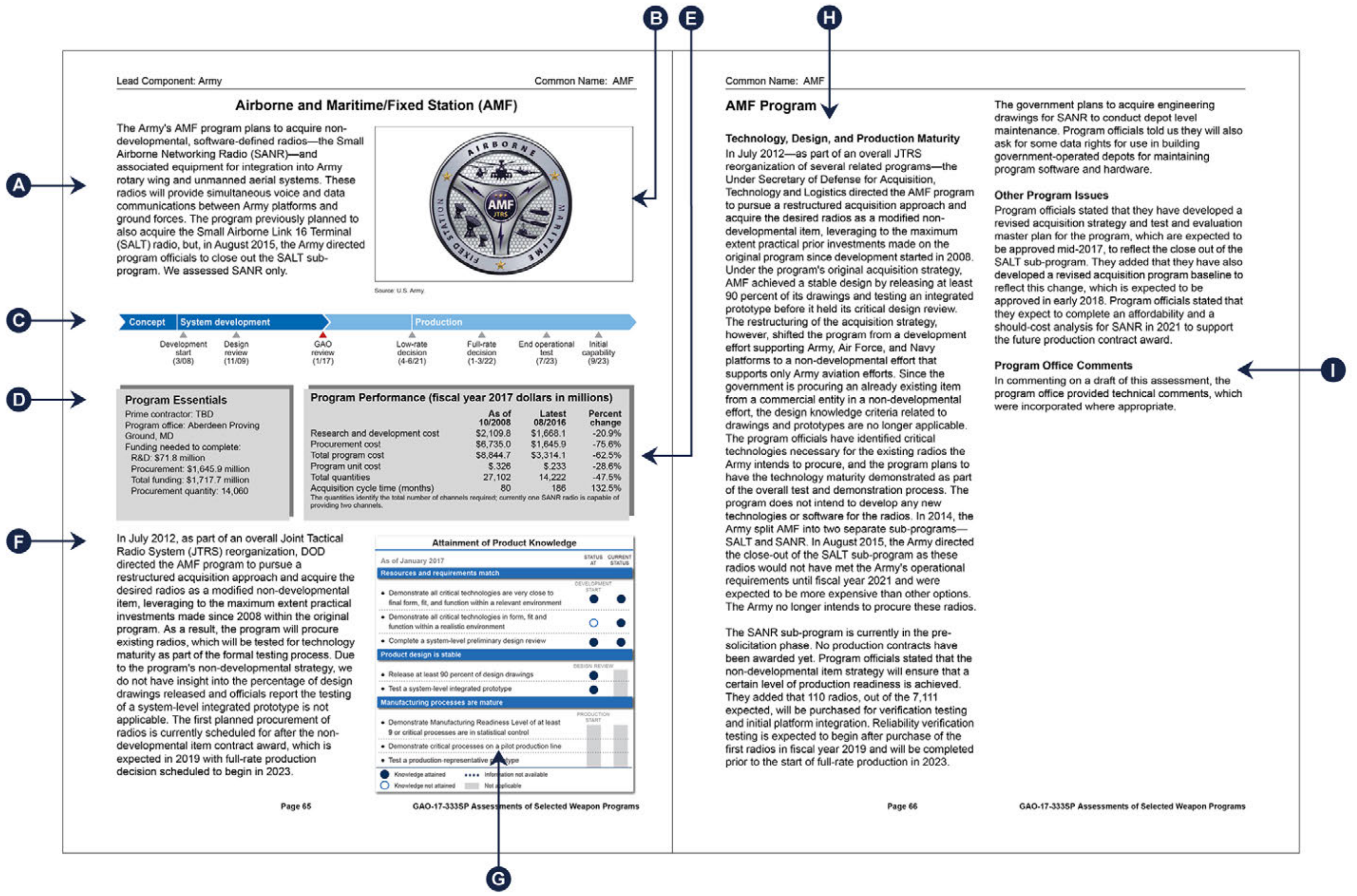
[35] In addition to the 54 program assessments, we separately assessed the Navy’s Frigate initiative, which is currently part of the Navy’s Littoral Combat Ship program.

Figure 16: Illustration of Program Two-Page Assessment



Lead Component: Army

Common Name: AMF

Airborne and Maritime/Fixed Station (AMF)

The Army's AMF program plans to acquire non-developmental, software-defined radios—the Small Airborne Networking Radio (SANR)—and associated equipment for integration into Army rotary wing and unmanned aerial systems. These radios will provide simultaneous voice and data communications between Army platforms and ground forces. The program previously planned to also acquire the Small Airborne Link 16 Terminal (SALT) radio, but, in August 2015, the Army directed program officials to close out the SALT sub-program. We assessed SANR only.

Source: U.S. Army

Concept | System development | Production

Development start (3/08)	Design review (11/09)	GAO review (1/17)	Low-rate decision (4-6/21)	Full-rate decision (1-3/22)	End operational test (7/23)	Initial capability (9/23)

Program Essentials
Prime contractor: TBD
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
R&D: $71.8 million
Procurement: $1,645.9 million
Total funding: $1,717.7 million
Procurement quantity: 14,060

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2008	Latest 08/2016	Percent change
Research and development cost	$2,109.8	$1,668.1	-20.9%
Procurement cost	$6,735.0	$1,645.9	-75.6%
Total program cost	$8,844.7	$3,314.1	-62.5%
Program unit cost	$.326	$.233	-28.6%
Total quantities	27,102	14,222	-47.5%
Acquisition cycle time (months)	80	186	132.5%

The quantities identify the total number of channels required; currently one SANR radio is capable of providing two channels.

In July 2012, as part of an overall Joint Tactical Radio System (JTRS) reorganization, DOD directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical investments made since 2008 within the original program. As a result, the program will procure existing radios, which will be tested for technology maturity as part of the formal testing process. Due to the program's non-developmental strategy, we do not have insight into the percentage of design drawings released and officials report the testing of a system-level integrated prototype is not applicable. The first planned procurement of radios is currently scheduled for after the non-developmental item contract award, which is expected in 2019 with full-rate production decision scheduled to begin in 2023.

Attainment of Product Knowledge

As of January 2017	Status at	Current status
Resources and requirements match	Development start	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	Design review	
• Release at least 90 percent of design drawings	●	▨
• Test a system-level integrated prototype	●	▨
Manufacturing processes are mature	Production start	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
•••• Information not available
▨ Not applicable

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Common Name: AMF

AMF Program

Technology, Design, and Production Maturity
In July 2012—as part of an overall JTRS reorganization of several related programs—the Under Secretary of Defense for Acquisition, Technology and Logistics directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical prior investments made on the original program since development started in 2008. Under the program's original acquisition strategy, AMF achieved a stable design by releasing at least 90 percent of its drawings and testing an integrated prototype before it held its critical design review. The restructuring of the acquisition strategy, however, shifted the program from a development effort supporting Army, Air Force, and Navy platforms to a non-developmental effort that supports only Army aviation efforts. Since the government is procuring an already existing item from a commercial entity in a non-developmental effort, the design knowledge criteria related to drawings and prototypes are no longer applicable. The program officials have identified critical technologies necessary for the existing radios the Army intends to procure, and the program plans to have the technology maturity demonstrated as part of the overall test and demonstration process. The program does not intend to develop any new technologies or software for the radios. In 2014, the Army split AMF into two separate sub-programs—SALT and SANR. In August 2015, the Army directed the close-out of the SALT sub-program as these radios would not have met the Army's operational requirements until fiscal year 2021 and were expected to be more expensive than other options. The Army no longer intends to procure these radios.

The SANR sub-program is currently in the pre-solicitation phase. No production contracts have been awarded yet. Program officials stated that the non-developmental item strategy will ensure that a certain level of production readiness is achieved. They added that 110 radios, out of the 7,111 expected, will be purchased for verification testing and initial platform integration. Reliability verification testing is expected to begin after purchase of the first radios in fiscal year 2019 and will be completed prior to the start of full-rate production in 2023.

The government plans to acquire engineering drawings for SANR to conduct depot level maintenance. Program officials told us they will also ask for some data rights for use in building government-operated depots for maintaining program software and hardware.

Other Program Issues
Program officials stated that they have developed a revised acquisition strategy and test and evaluation master plan for the program, which are expected to be approved mid-2017, to reflect the close out of the SALT sub-program. They added that they have also developed a revised acquisition program baseline to reflect this change, which is expected to be approved in early 2018. Program officials stated that they expect to complete an affordability and a should-cost analysis for SANR in 2021 to support the future production contract award.

Program Office Comments
In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where appropriate.

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Ⓐ Program description

Ⓑ Illustration or photo of system

Ⓒ Schedule timeline identifying key dates for the program including the start of development, major design reviews, production decisions, and planned operational capability

Ⓓ **Program Essentials** Programmatic information including the prime contractor, program office location, and funding needed to complete

Ⓔ **Program Performance** Cost and schedule baseline estimates and the latest estimate provided as of January 2017

Ⓕ Brief summary describing the program's implementation of knowledge-based acquisition practices and its current status

Ⓖ **Attainment of Product Knowledge** Depiction of selected knowledge-based practices and the program's progress in attaining that knowledge

Ⓗ Assessment of program's technology, design, and production maturity, as well as other program issues

Ⓘ **Program Office Comments** General comments provided by the cognizant program office

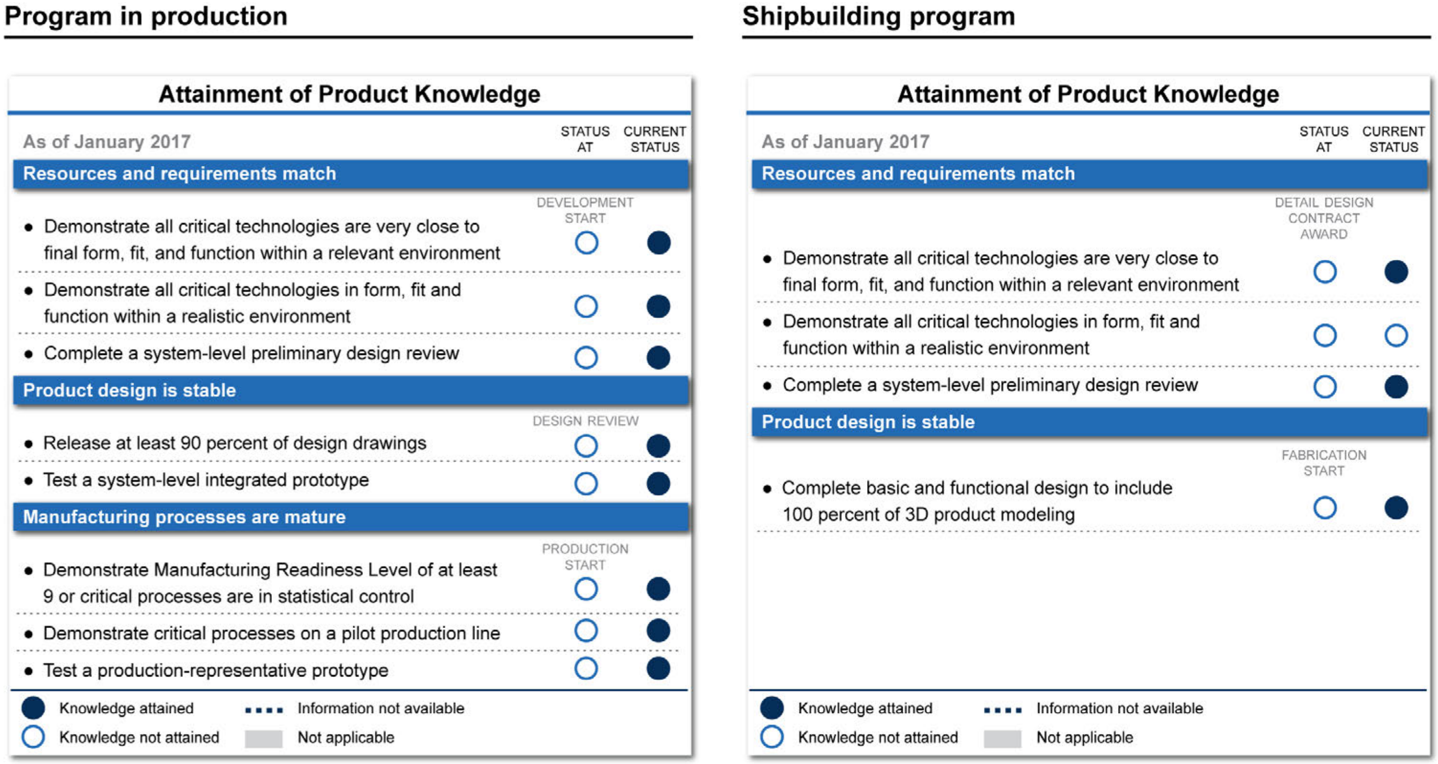
Source: GAO analysis. | GAO-17-333SP

For our two-page assessments, we depict the extent of knowledge gained in a program at the time of our review with a scorecard and narrative summary at the bottom of the first page of each assessment. These scorecards display key knowledge-based acquisition practices that should be implemented by certain points in the acquisition process. The more knowledge the program has attained by each of these key points, the more likely the weapon system will be delivered within its estimated cost and schedule. A knowledge deficit means the program is proceeding without sufficient knowledge about its technologies, design, or manufacturing processes, and faces unresolved risks that could lead to cost increases and schedule delays.

For each program, we identify a knowledge-based practice that has been implemented with a closed circle. We identify a knowledge-based practice that has not yet been implemented with an open circle. If the program did not provide us with enough information to make a determination, we show this with a dashed line. A knowledge-based practice that is not applicable to the program is grayed out. A knowledge-based practice may not be applicable to a particular program if the point in the acquisition cycle when the practice should be implemented has not yet been reached, or if the particular practice is not relevant to the program. For programs that have not yet entered system development, we show a projection of knowledge attained for the first three practices. For programs that have entered system development but not yet held a critical design review, we assess actual knowledge attained for these three practices. For programs that have held a critical design review but not yet entered production, we assess knowledge attained for the first five practices. For programs that have entered production, we assess knowledge attained for all eight practices.

We make adjustments to both the key points in the acquisition cycle and the applicable knowledge-based practices for shipbuilding programs. For shipbuilding programs that have not yet awarded a detail design contract, we show a projection of knowledge attained for the first three practices. For shipbuilding programs that have awarded this contract but not yet started construction, we would assess actual knowledge attained for these three practices. For shipbuilding programs that have started construction, we assess the knowledge attained for the first four practices. We do not assess the remaining four practices for shipbuilding programs as they are not applicable for these programs. See figure 17 for examples of the knowledge scorecards we use to assess these different types of programs.

Figure 17: Examples of Knowledge Scorecards



Program in production

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	○	●
• Test a production-representative prototype	○	●

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained ▨ Not applicable

Shipbuilding program

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable		
	FABRICATION START	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained ▨ Not applicable

Source: GAO. | GAO-17-333SP

Statement on Small Business Participation

Pursuant to a mandate in a report for the National Defense Authorization Act for Fiscal Year 2013, we reviewed whether individual subcontracting reports from a program's prime contractor or contractors were acknowledged—reviewed by the agency that awarded the contract and found to have no errors or other issues—on the Electronic Subcontracting Reporting System (eSRS).[36] Federal law requires prime contractors to make a good faith effort to award a portion of their subcontracts to small businesses and in some cases to have small business subcontracting plans.[37] We reviewed this information for 78 of the major defense

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[36] H.R. Rep. No. 112-479, at 284 (2012).

[37] Small business subcontracting plans, which are required by the Small Business Act, 15 U.S.C. § 637(d), establish goals for small business subcontracting and describe how the contractor plans to achieve those goals.

acquisition programs in our assessment that reported contract information in their December 2015 Selected Acquisition Report (SAR) submissions. The contract numbers for each program’s prime contracts were entered into the eSRS database to determine whether the individual subcontracting reports from the prime contractors had been acknowledged by the government. The government uses individual subcontracting reports on eSRS as one method of monitoring small business participation, as the report includes goals for small business subcontracting. Not all prime contracts for major defense acquisition programs are required to submit individual subcontracting reports. For example, some contractors report small business participation at a corporate level as opposed to a program level and these data are not captured in the individual subcontracting reports. Information gathered for this analysis is presented in appendix VI.

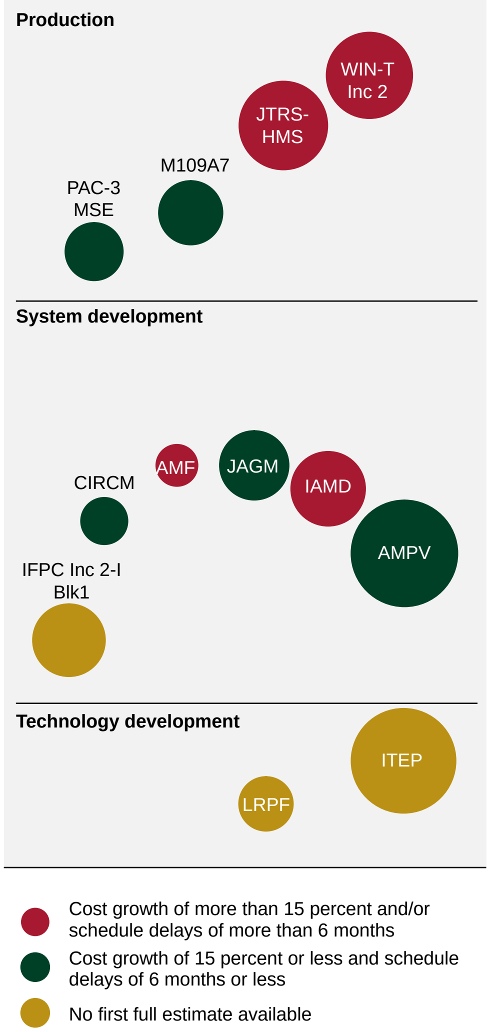
Army Programs Summary

We completed individual assessments on 12 of the Army's 20 current and future major defense acquisition programs. Of these 12 programs, 10 are, for the most part, in system development or early production, while 2 are future programs that DOD expects to enter system development in the next few years. We found the Army currently estimates a need of $64.4 billion in funding to complete the acquisition of these 12 programs. In addition, we compared these 12 programs' first full estimates of cost and schedule, as available, with their current estimates and found:

- net cost growth totals $200 million almost all of which was realized over the past five years, and
- program schedule delays average approximately 21 months.

Further, 2 of the 12 programs—the Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc 2-I Block 1) and Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE) programs—completed all the activities associated with the applicable knowledge based best practices we assess as the programs reach their knowledge points. Yet, only IFPC Inc 2-I Block 1 completed all applicable activities on time.

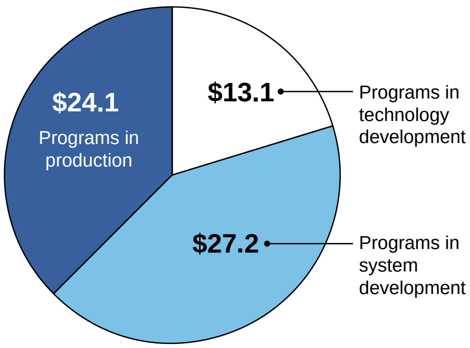
Acquisition Phase and Size of the 12 Programs Assessed



Note: Bubble size is based on each program's currently estimated future funding needed.

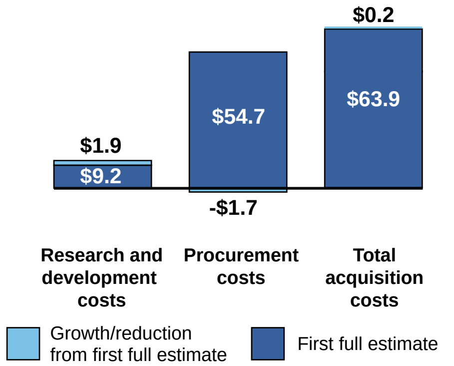
Currently Estimated Acquisition Cost for the 12 Programs Assessed

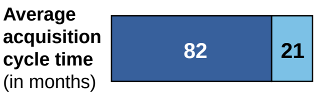
Fiscal year 2017 dollars in billions



Cost and Schedule Growth on 9 Programs in the Current Portfolio

Fiscal year 2017 dollars in billions





Note: For acquisition cycle time only 8 programs were assessed as not all programs contained sufficient information within their first full estimates to determine acquisition cycle time. In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match		Knowledge Point 2 Product design is stable		Knowledge Point 3 Manufacturing processes are mature	
	At KP1	Current Status	At KP2	Current Status	At KP3	Current Status
AMF	○	●	●	▨	KP 3 in future	
AMPV	○	●	○	○	KP 3 in future	
CIRCM	○	○	●	●	KP 3 in future	
IAMD	○	○	○	●	KP 3 in future	
IFPC Inc 2-I Blk 1	●	●	KP 2 in future		KP 3 in future	
JAGM	○	○	●	●	KP 3 in future	
JTRS-HMS	○	●	○	●	○	○
M109A7	- - -	●	- - -	●	○	○
PAC-3 MSE	○	●	○	●	○	●
WIN-T Inc 2	○	●	- - - - - - -		○	●

● All applicable knowledge practices completed
○ One or more applicable knowledge practices were not completed
▨ Knowledge practice is not applicable
- - - Information not available for knowledge practice

Source: GAO analysis of DOD data. | GAO-17-333SP

Army Program Assessments

Airborne and Maritime/Fixed Station (AMF)

The Army's AMF program plans to acquire non-developmental, software-defined radios—the Small Airborne Networking Radio (SANR)—and associated equipment for integration into Army rotary wing and unmanned aerial systems. These radios will provide simultaneous voice and data communications between Army platforms and ground forces. The program previously planned to also acquire the Small Airborne Link 16 Terminal (SALT) radio, but, in August 2015, the Army directed program officials to close out the SALT sub-program. We assessed SANR only.

Source: U.S. Army.

Concept | **System development** | **Production**

Development start (3/08)	Design review (11/09)	GAO review (1/17)	Low-rate decision (4-6/21)	Full-rate decision (1-3/22)	End operational test (7/23)	Initial capability (9/23)

Program Essentials

Prime contractor: TBD
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
- R&D: $71.8 million
- Procurement: $1,645.9 million
- Total funding: $1,717.7 million
- Procurement quantity: 14,060

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2008	Latest 08/2016	Percent change
Research and development cost	$2,109.8	$1,668.1	-20.9%
Procurement cost	$6,735.0	$1,645.9	-75.6%
Total program cost	$8,844.7	$3,314.1	-62.5%
Program unit cost	$.326	$.233	-28.6%
Total quantities	27,102	14,222	-47.5%
Acquisition cycle time (months)	80	186	132.5%

The quantities identify the total number of channels required; currently one SANR radio is capable of providing two channels.

In July 2012, as part of an overall Joint Tactical Radio System (JTRS) reorganization, DOD directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical investments made since 2008 within the original program. As a result, the program will procure existing radios, which will be tested for technology maturity as part of the formal testing process. Due to the program's non-developmental strategy, we do not have insight into the percentage of design drawings released and officials report the testing of a system-level integrated prototype is not applicable. The first planned procurement of radios is currently scheduled for after the non-developmental item contract award, which is expected in 2019 with full-rate production decision scheduled to begin in 2023.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	▨
• Test a system-level integrated prototype	●	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

AMF Program

Technology, Design, and Production Maturity

In July 2012—as part of an overall JTRS reorganization of several related programs—the Under Secretary of Defense for Acquisition, Technology and Logistics directed the AMF program to pursue a restructured acquisition approach and acquire the desired radios as a modified non-developmental item, leveraging to the maximum extent practical prior investments made on the original program since development started in 2008. Under the program's original acquisition strategy, AMF achieved a stable design by releasing at least 90 percent of its drawings and testing an integrated prototype before it held its critical design review. The restructuring of the acquisition strategy, however, shifted the program from a development effort supporting Army, Air Force, and Navy platforms to a non-developmental effort that supports only Army aviation efforts. Since the government is procuring an already existing item from a commercial entity in a non-developmental effort, the design knowledge criteria related to drawings and prototypes are no longer applicable. The program officials have identified critical technologies necessary for the existing radios the Army intends to procure, and the program plans to have the technology maturity demonstrated as part of the overall test and demonstration process. The program does not intend to develop any new technologies or software for the radios. In 2014, the Army split AMF into two separate sub-programs—SALT and SANR. In August 2015, the Army directed the close-out of the SALT sub-program as these radios would not have met the Army's operational requirements until fiscal year 2021 and were expected to be more expensive than other options. The Army no longer intends to procure these radios.

The SANR sub-program is currently in the pre-solicitation phase. No production contracts have been awarded yet. Program officials stated that the non-developmental item strategy will ensure that a certain level of production readiness is achieved. They added that 110 radios, out of the 7,111 expected, will be purchased for verification testing and initial platform integration. Reliability verification testing is expected to begin after purchase of the first radios in fiscal year 2019 and will be completed prior to the start of full-rate production in 2023.

The government plans to acquire engineering drawings for SANR to conduct depot level maintenance. Program officials told us they will also ask for some data rights for use in building government-operated depots for maintaining program software and hardware.

Other Program Issues

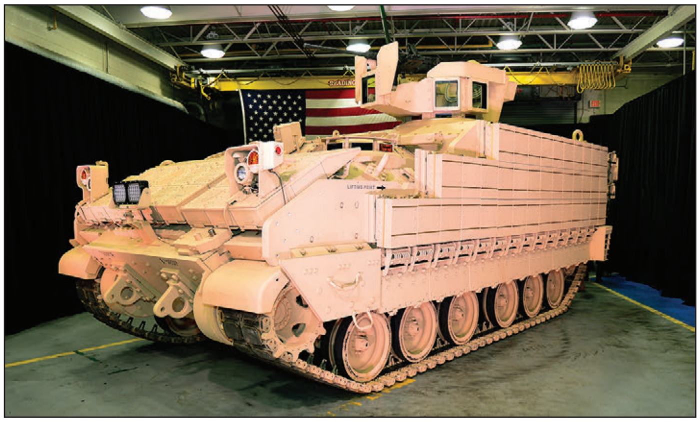
Program officials stated that they have developed a revised acquisition strategy and test and evaluation master plan for the program, which are expected to be approved mid-2017, to reflect the close out of the SALT sub-program. They added that they have also developed a revised acquisition program baseline to reflect this change, which is expected to be approved in early 2018. Program officials stated that they expect to complete an affordability and a should-cost analysis for SANR in 2021 to support the future production contract award.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where appropriate.

Armored Multi-Purpose Vehicle (AMPV)

The Army's Armored Multi-Purpose Vehicle (AMPV) is the replacement to the M113 family of vehicles at the Brigade level and below. The AMPV will replace the M113 in five mission roles: general purpose, medical evacuation, medical treatment, mortar carrier, and mission command. The Army determined that development of the AMPV is necessary due to mobility, survivability, and force protection deficiencies identified with the M113, as well as space, weight, power, and cooling limitations that prevent the incorporation of future technologies.



Source: U. S. Army.

Program Essentials

Prime contractor: BAE Systems
Program office: Warren, MI
Funding needed to complete:
  R&D: $661.5 million
  Procurement: $10,030.7 million
  Total funding: $10,692.2 million
  Procurement quantity: 2,897

Program Performance (fiscal year 2017 dollars in millions)

	As of 05/2015	Latest 12/2015	Percent change
Research and development cost	$1,018.0	$1,043.6	2.5%
Procurement cost	$10,030.5	$10,030.7	0.0%
Total program cost	$11,048.5	$11,074.3	0.2%
Program unit cost	$3.763	$3.772	0.2%
Total quantities	2,936	2,936	0.0%
Acquisition cycle time (months)	87	87	0.0%

The AMPV program held a critical design review in June 2016, with its critical technologies mature and a design that was stable, but not demonstrated. Following this review, the program received approval to modify a key performance requirement and several system attributes, which DOD had previously judged AMPV would be challenged to meet. To support design demonstration, BAE Systems started fabricating prototype vehicles in May 2016, with the first being delivered in December 2016. Delays related to engineering drawing releases, manufacturing planning, and ballistic weld certification have impeded fabrication work, although program officials noted these issues have largely been overcome. The program has also identified and is mitigating interface issues between AMPV and certain platforms it will rely upon for communication and networking capabilities.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

AMPV Program

Technology and Design Maturity

The AMPV program entered system development in December 2014 with its critical technologies fully mature as determined by an independent review team. According to program officials, while the AMPV design utilizes a new hull design, a majority of subsystems are derived from existing vehicle designs.

Although the program held its critical design review in June 2016 with over 90 percent of its design drawings released to manufacturing, the program had not yet demonstrated a system-level integrated prototype. BAE Systems started fabricating AMPV prototype vehicles in May 2016 to support design demonstration and developmental testing. However, delays related to releasing engineering drawings and manufacturing planning efforts disrupted these fabrication activities. Program officials report that these issues are being addressed and the program delivered its first prototype in December 2016.

Prior to AMPV’s critical design review, the Office of the Deputy Assistant Secretary of Defense for Systems Engineering assessed that the AMPV preliminary design would be challenged to meet survivability and force protection requirements and identified a need to modify these requirements to match the capabilities that the AMPV was likely to provide. In response, the program requested and received approval from the Army Requirements Oversight Council to modify the system’s survivability requirement as well as several key system attributes. In September 2016, the Joint Requirements Oversight Council validated the survivability requirement change. AMPV’s survivability and force protection is still expected to exceed that of the M113 vehicle it is intended to replace.

Production Maturity

Although the AMPV program expects to demonstrate its critical manufacturing processes on a pilot production line, it does not anticipate that these processes will achieve statistical control prior to production start in February 2019. In addition, BAE Systems has had difficulty attaining ballistic weld certification—essential for the government ensuring that the contractor can successfully weld ballistic materials—due to qualification test failures. While this delayed deliveries of ballistic hulls, a key vehicle component, this issue has been resolved according to program officials. BAE redesigned these welds and validated their design in August 2016.

Other Program Issues

AMPV is dependent on other programs for its key communication and networking capabilities. While most systems providing these capabilities exist on current platforms, the program has unresolved interface issues with some of them. For example, the Manpack radios—separately produced as part of the Army's Joint Tactical Radio System Handheld, Manpack, and Small Form Fit (JTRS HMS) Radios program—requires design changes to be fully compatible with AMPV's interface. To mitigate the Manpack radio integration risk, program officials plan to include a legacy radio platform in the AMPV's design. However, if other communications and networking systems—some of which have experienced their own developmental challenges—are not available when needed to support AMPV's testing and fielding, the Army will likely face a choice of adjusting the AMPV's schedule or accepting reduced capabilities.

Program Office Comments

In addition to providing technical comments, which we incorporated where appropriate, the program office noted that the program successfully rolled-out the first AMPV prototype on-time in December 2016. Further, the program office stated that the prototypes are built on existing production lines using production-representative work instructions, material, manpower, and tooling. These manufacturing processes are being continuously updated and refined as prototypes move down the line, and will stabilize and mature in fiscal year 2017. The program successfully completed ballistic weld joint redesign and testing to confirm the armor weldments met ballistic shock requirements. The associated welding procedures used for building hulls are now fully certified and there are no schedule delays. The program is coordinating with other program offices to understand the detailed interfaces required to ensure seamless integration of emerging radios and does not currently anticipate any program schedule delays.

Common Infrared Countermeasure (CIRCM)

The Army's CIRCM is the next generation of Advanced Threat Infrared Countermeasures (ATIRCM) designed to defend aircraft from infrared-guided missiles. The program is developing a laser-based system for use with a missile warning system and countermeasure dispenser that deploys expendables, such as flares and chaff. CIRCM will be installed on rotary-wing, tilt-rotor, and small fixed-wing aircraft across DOD. CIRCM was originally started as a subprogram under the ATIRCM/Common Missile Warning System.

Source: Northrop Grumman.

Program Essentials

Prime contractor: Northrop Grumman
Program office: Huntsville, Alabama
Funding needed to complete:
  R&D: $379.7 million
  Procurement: $1,836.3 million
  Total funding: $2,216.0 million
  Procurement quantity: 1,076

Program Performance (fiscal year 2017 dollars in millions)

	As of 07/2016	Latest 10/2016	Percent change
Research and development cost	$777.4	$777.4	0.0%
Procurement cost	$1,836.3	$1,836.3	0.0%
Total program cost	$2,613.7	$2,613.7	0.0%
Program unit cost	$2.325	$2.325	0.0%
Total quantities	1,124	1,124	0.0%
Acquisition cycle time (months)	115	115	0.0%

The CIRCM program entered system development in August 2015 with its critical technologies approaching maturity based on the results of a technology readiness assessment conducted in December 2014. The independent review team was not able to determine whether any of the critical technologies achieved full maturity as testing of the CIRCM prototypes in an operational environment was not performed. The program completed its critical design review in October 2016, with a stable design and almost all drawings released to manufacturing. The program office has identified key manufacturing risk areas and included them in its plans for a pilot line validation and production readiness review to assess the program's readiness to enter production.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

CIRCM Program

Technology Maturity

The CIRCM program entered system development in August 2015 with its critical technologies approaching maturity. In December 2014, an independent review team conducted an assessment of the program's nine critical technologies in a relevant environment—including the gimbal assembly, camera assembly, the quantum cascade laser, and others—and determined that all technologies were nearing maturity. However, according to a November 2016 program document, none of the technologies have achieved maturity yet. The program originally planned to enter the acquisition cycle at system development. However, after competitive prototyping, the program determined none of the vendors had built prototypes with the required technology readiness levels and all required major redesigns to meet weight requirements. The key risks going into the technology development phase were the CIRCM's weight, probability of countermeasure, and reliability. The program entered the acquisition cycle at technology development, which resulted in allowing vendors 3 years to further develop their designs. Government test results indicate that weight, probability of countermeasure, and reliability are meeting or exceeding exit criteria and/or the system requirements.

Design Maturity

The program completed its critical design review (CDR) in October 2016 and reports that the design is stable based on the number of design drawings released to manufacturing. One hundred percent of the drawings for the CIRCM system and 95 percent of the drawings for the modification kits—which include the hardware, wiring harness, and cables necessary to install CIRCM on each aircraft—have been delivered. The program office had one critical action from the CDR and closed it in January 2017.

Production Maturity

According to program officials, key manufacturing risk areas have been identified and included in the program's pilot line validation and production readiness review plans. Both of these events will cover all manufacturing concerns to determine the program's readiness to enter production. Pilot line validations are conducted to validate manufacturing capabilities are in place to produce CIRCM units and address manufacturing maturity progression toward achieving a production capability and capacity that will meet full rate production requirements. This validation will be conducted while initial CIRCM units are manufactured so that instructions, equipment, tooling, test equipment, and workers can be observed. The Production Readiness Review, scheduled for August 2017, determines if the system design is ready for production and if the developer has accomplished adequate production planning for entering both low-rate initial production and full-rate production.

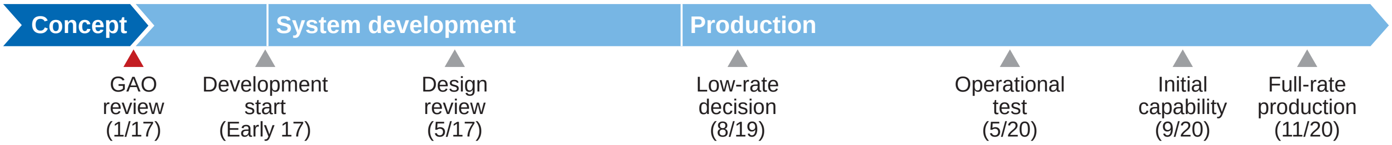
Program Office Comments

The program office reports that it completed CDR in October 2016 and is preparing for pilot line validations and production readiness reviews to validate the contractor's ability to manufacture the final CIRCM design in the quantities required. The CIRCM program has begun building production representative articles based on the design presented at the design review, which will begin system level developmental testing in preparation for operational testing scheduled for fiscal year 2019. According to program officials, CIRCM remains on track for completion of the system development phase and movement towards full-rate production readiness within the cost, schedule, and performance requirements set forth in its Acquisition Program Baseline. The program also provided technical comments, which were incorporated where deemed appropriate.

Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc 2-I Block 1))

The Army's IFPC Inc 2-I is a follow-on effort to enhance and extend the range of the first IFPC increment, which provided a short-range capability to counter threats from rockets, artillery, and mortars. IFPC Inc 2-I consists of four separate sub-systems: an existing sensor; an interceptor; a command and control system; and a new multi-mission launcher (MML) being developed by the Army. IFPC Inc 2-I consists of three blocks. Block 1 adds the capability to counter cruise missiles and unmanned aircraft. We assessed Inc 2-I Block 1.

Source: U.S. Army.



Program Essentials

Prime contractors: Aviation and Missile Research, Development and Engineering Center; Letterkenny Army Depot
Program office: Huntsville, Alabama
Funding needed to complete:
R&D: $404.3 million
Procurement: $2,729.6 million
Total funding: $3,133.9 million
Procurement quantity: 368

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 09/2016	Percent change
Research and development cost	NA	$736.8	NA
Procurement cost	NA	$2,729.6	NA
Total program cost	NA	$3,466.5	NA
Program unit cost	NA	$9.420	NA
Total quantities	NA	368	NA
Acquisition cycle time (months)	NA	46	NA

The IFPC Inc 2-I Block 1 program plans to enter development with no critical technologies. The program has released all design drawings and considers its system design stable ahead of the planned May 2017 critical design review. However, this stability may be compromised if changes are needed before the May 2017 critical design review to integrate the MML with the other three subsystems. The program continues to develop the MML at two Army facilities, a strategy that was previously determined to be the most cost effective. Program officials acknowledged that they have a limited amount of time and flexibility in their current development schedule to correct any deficiencies identified during developmental testing. As a result, this optimistic schedule could leave the program at risk for unplanned cost increases and schedule delays to correct any such deficiencies that emerge.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
- Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▨	▨
- Demonstrate all critical technologies in form, fit and function within a realistic environment	▨	▨
- Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
- Release at least 90 percent of design drawings	▨	▨
- Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
- Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
- Demonstrate critical processes on a pilot production line	▨	▨
- Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

IFPC Inc 2-I Block 1 Program

Technology Maturity

In May 2016, the Army completed a technology readiness assessment for the IFPC Inc 2-I Block 1 program that identified no critical technologies ahead of the program's planned entry into system development. Although three of the four sub-systems that comprise IFPC Inc 2-I Block 1 are either fielded or in production, officials acknowledged that these systems pose potential integration challenges to Block 1 system development because their capabilities will be used in new ways to prosecute different threats. The AIM-9X missile, the designated interceptor, was originally developed as an air-to-air missile and designed to be fired from Navy tactical aircraft. The Army is relying on its Integrated Air and Missile Defense program to produce the command and control system, which is currently designed to control the Patriot missile launcher and radar system. Previously, we found the IAMD program faces its own development challenges. The program office also intends to use the existing Sentinel air defense radar as its sensor component.

The Army will develop and produce the fourth system—the multi-mission launcher (MML)—at two facilities: the Aviation and Missile Research, Development, and Engineering Center (AMRDEC) and Letterkenny Army Depot (LEAD). According to program officials, AMRDEC is responsible for developing the MML units used for testing during system development, whereas LEAD will assume responsibility for MML low-rate initial production.

Design Maturity

According to program officials, the program has released all of its expected engineering drawings. However, program officials stated the prototype design of the MML presented at the program's preliminary design review in September 2015 is being assessed and updated, as necessary, in preparation for the critical design review (CDR) in May 2017. The CDR will evaluate the integration of the MML with the existing sensor, interceptor, and command and control system. The program has no plans for additional prototyping during system development following its CDR.

Program officials acknowledged the program schedule is oriented on successful testing outcomes throughout system development. As a result, program officials acknowledge there is limited time available to correct any deficiencies that may be found during testing before production begins. This optimistic schedule could leave the program at risk for unplanned cost increases and schedule delays to correct those deficiencies.

Production Maturity

Program officials stated that LEAD has the capability and capacity to manufacture 60 MML units per year, but they are unsure how easily the depot can exceed that number. The current production schedule increases the annual MML production rate to a maximum of 72 units in fiscal year 2022. Program officials stated they are committed to utilizing Army facilities for MML development and production and are developing mitigation strategies, including identifying additional Army sources for production tooling equipment to supplement the equipment already available at LEAD. However, program officials stated that, should they determine LEAD is unable to manufacture the MML at required rates, they have the option of soliciting proposals from contractors for MML production ahead of the IFPC Inc 2-I Block 1 full rate production decision in 2020.

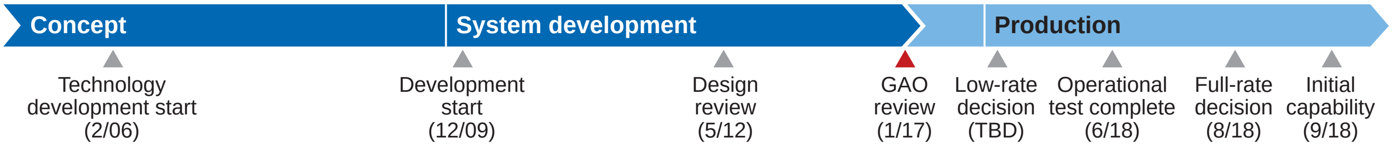
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical commments, which were incorporated where deemed appropriate.

Integrated Air and Missile Defense (IAMD)

The Army's Integrated Air and Missile Defense (IAMD) program is being developed to network sensors, weapons, and a common battle command system across an integrated fire control network to support the engagement of air and missile threats. The IAMD battle command system will provide a capability to control and manage IAMD sensors and weapons, such as the Sentinel radar and Patriot launcher and radar, through an interface module that supplies battle management data and enables networked operations.

Source: Northrop Grumman.



Program Essentials

Prime contractors: Northrop Grumman Space & Mission Systems Corp., Raytheon Company
Program office: Redstone Arsenal, AL
Funding needed to complete:
  R&D: $715.7 million
  Procurement: $3,802.0 million
  Total funding: $4,517.7 million
  Procurement quantity: 427

Program Performance (fiscal year 2017 dollars in millions)

	As of 12/2009	Latest 08/2016	Percent change
Research and development cost	$1,730.2	$2,678.6	54.8%
Procurement cost	$3,724.2	$3,822.7	2.6%
Total program cost	$5,454.4	$6,501.2	19.2%
Program unit cost	$18.427	$14.675	-20.4%
Total quantities	296	443	49.7%
Acquisition cycle time (months)	80	105	31.3%

IAMD critical technologies achieved full maturity in 2016—more than 6 years after development start. Best practices recommend that technology maturity be achieved prior to starting development. The program's low-rate production decision has been delayed more than 4 months to allot more time for developmental testing. According to program officials, the root causes for this delay include the program office's inability to schedule test range time as well as the extra time required for review of recent testing results. Program officials noted that it will be challenging to start operational testing by the planned September 2017 date and anticipate changes to developmental and operational testing schedules going forward.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

IAMD Program

Technology Maturity

As of September 2016, the IAMD program demonstrated that all of its critical technologies—integrated battle command, integrated defense design, integrated fire control network, and distributed track management—are fully mature. This achievement comes over 6 years after the start of system development—a schedule that is inconsistent with best practices.

Design Maturity

IAMD completed its critical design review with a stable design in 2012, but the total number of design drawings has increased, with program officials reporting that 5 percent of them still need to be released before production starts. Program officials report they have released 95 percent of IAMD's design drawings. In addition, IAMD software development delays, which we have previously reported, persist. Program officials stated that, most recently, the program experienced software challenges going into an IAMD operational assessment with some software upgrades remaining undelivered. However, these officials noted the IAMD program will need software updates on a continuing basis due to threat changes. The program is also currently developing a software version (version 4.0) that officials anticipate will incorporate fixes for previous software deficiencies.

Production Maturity

The Army has delayed the IAMD low-rate production decision—previously planned for August 2016—to allot more time for developmental testing. According to program officials, the root causes for this delay include limited access to needed test resources, such as test ranges, as well as extra time required for reviewing the limited user test results. IAMD full-rate production start remains planned for fiscal year 2018.

Other Program Issues

The program conducted "limited user testing" from March to May 2016 to collect data on the IAMD's system of systems operational effectiveness, suitability, and survivability. This assessment of IAMD was designed to evaluate its ability to defeat aerial threats in an operationally realistic environment and determine hardware and software maturity, among other goals.

As a result of the limited user testing, the Army Operational Test Command made several recommendations to address issues with IAMD's operational effectiveness, suitability, and survivability. These recommendations are based on tester observations made during the test and do not reflect the Army Test and Evaluation Command's final evaluation recommendations, which the U.S. Army Evaluation Center is currently developing based on the results of this test. According to program officials, IAMD completed successful flight tests in 2016, which demonstrated new capabilities. For example, officials noted a successful first flight test where a PAC-3 missile intercepted a tactical ballistic missile using IAMD software and a composite tracker.

Program officials noted it will be challenging to start operational testing by September 2017. They stated that IAMD's developmental and operational testing schedules are likely to change. The program's initial operational capability date has been moved from June 2018 to September 2018, but program officials stated that this is still within the program's acquisition program baseline parameters. According to program officials, this minor schedule change will provide the program more time to test, analyze, fix, and re-test.

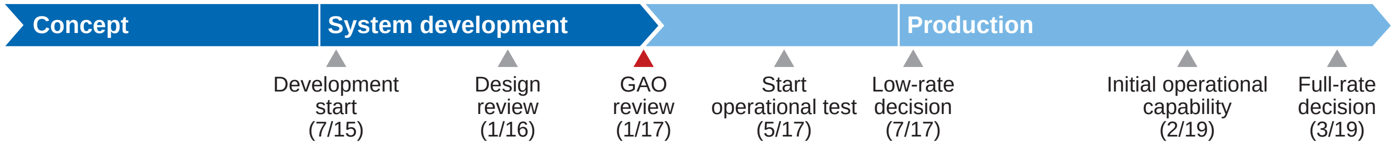
Program Office Comments

The limited user testing provided less than satisfactory results per the Army Test and Evaluation Command's final assessment. As a result, the Army Acquisition Executive placed the Milestone C decision on hold until the software deficiencies identified were resolved. According to program officials, the Milestone C decision is expected to occur in 2017. Officials also noted the initial operational capability date will be adjusted accordingly to accommodate the necessary initial operational testing needed prior to fielding of the system.

Joint Air-to-Ground Missile (JAGM)

The Joint Air-to-Ground Missile is an Army-led program with joint requirements from the Navy and Marine Corps. The missile is designed to be air-launched from helicopters and unmanned aircraft systems to target tanks, light armored vehicles, missile launchers, bunkers, and buildings. It is intended to provide precision attack capabilities no matter the time of day or weather conditions. JAGM will replace all Hellfire missile variants.

Source: U.S. Army.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Redstone Arsenal, AL
Funding needed to complete:
R&D: $95.5 million
Procurement: $4,831.9 million
Total funding: $4,927.4 million
Procurement quantity: 26,319

Program Performance (fiscal year 2017 dollars in millions)

	As of 09/2015	Latest 08/2016	Percent change
Research and development cost	$1,008.0	$996.3	-1.2%
Procurement cost	$4,833.0	$4,858.0	0.5%
Total program cost	$5,841.0	$5,854.3	0.2%
Program unit cost	$.221	$.221	0.2%
Total quantities	26,437	26,437	0.0%
Acquisition cycle time (months)	38	38	0.0%

The Army has fully matured all three of the JAGM program's critical technologies. Following a 2012 program restructuring, the Army redesigned JAGM to employ existing Hellfire missile components. DOD subsequently waived the requirement to complete a preliminary design review (PDR) of the redesigned missile prior to development start. The Army held a critical design review (CDR) in January 2016, which assessed the JAGM design as stable. The program has delayed initial operational testing due to a requirement for new Apache platform software and will instead begin a limited user test in May 2017. The program plans to manufacture JAGM on the existing production line used for Hellfire missiles, and program officials told us they expect all production processes to be mature prior to the start of low-rate production in July 2017.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	○
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

JAGM Program

Technology Maturity

JAGM has three critical technologies—the guidance seeker assembly/sensor platform, sensor software, and mission software, all of which the program assessed as mature following two successful test shot events in June 2016. JAGM components, including the motor, warhead, and electronics, are common with the existing Hellfire missile. The Army's decision to include these components in the JAGM design followed a 2012 restructuring of the program, which included extending technology development by more than 2 years to address affordability concerns and risk reduction needs.

Design Maturity

The Army completed a system-level PDR for JAGM in June 2010. Following the program's 2012 restructuring, the Army implemented design changes to the missile, but DOD waived the requirement to conduct a PDR for the new design before the start of system development. At the CDR in January 2016, the program reported that the number of drawings expected had increased from 180 to 198. Program officials reported that nearly 97 percent of these drawings have been released and that the increase in drawings was due to design changes to existing hardware as well as a new drawing for the guidance section. The CDR determined that the design was stable and able to meet system performance requirements. The program held five flight tests of a system level prototype prior to the CDR and held an additional two tests in 2016, including the first missile test from a MQ-1C Gray Eagle.

JAGM officials reported a 5 month delay to the production of engineering and manufacturing development missiles because of a manufacturing defect in the seeker head assembly's dual-sensor interface circuit card, which may have resulted in the failure of the sensor. The contractor has since redesigned the interface to new specifications. The program also found that the material used to coat a portion of the transceiver failed under vibration loads. The contractor plans to use a different coating beginning with the 81st testing missile it produces, but program officials do not anticipate performance limitations to earlier missiles or schedule disruptions.

Production Maturity

JAGM will be manufactured at the same facility as the Hellfire missile. The program office is tracking 15 different metrics related to hardware and software to assess JAGM's readiness for production. According to program officials, these metrics currently meet expected values, and the program expects all production processes to be mature prior to the start of low-rate production in July 2017.

Other Program Issues

The Army has delayed initial operational testing and evaluation (IOT&E) by 2 years because the AH-64 Apache helicopter's current software—used to launch Hellfire missiles—requires more pilot input to access JAGM functionality than expected. New platform software in development for integration and testing in fiscal year 2018 will enable pilots to select the full range of options with far less physical interface with the platform. Flight testing of this software is planned for August 2018 to be followed by IOT&E. In the interim, the program has planned a limited user test in May 2017 of 10 missile shots with existing platform software and hardware to demonstrate the missile's capabilities. Program officials told us they do not expect any material changes to the missile between the limited user test and IOT&E.

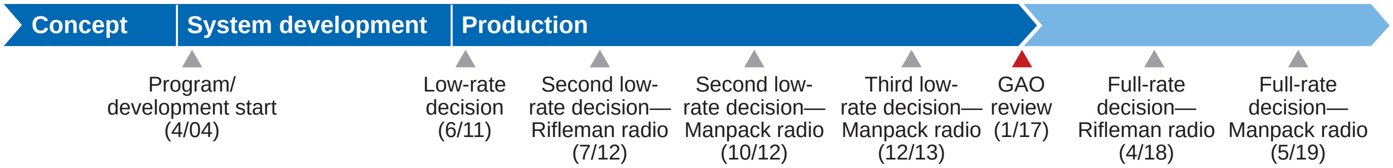
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where appropriate.

Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)

DOD's Joint Tactical Radio System (JTRS) program, now restructured, was developing software-defined radios to interoperate with existing radios and increase communications and networking capabilities. The Army's JTRS HMS program continues efforts to procure two radios—the Rifleman and Manpack radios. A subset of Manpack radios are designed to operate with the Mobile User Objective System (MUOS)—a Navy satellite communication system planned to serve a worldwide, multiservice population of mobile and fixed-site terminal users.

Source: © 2012 General Dynamics C4S.



Program Essentials

Prime contractors: Harris Corporation, Thales Defense & Security
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
  R&D: $156.4 million
  Procurement: $7,073.9 million
  Total funding: $7,230.4 million
  Procurement quantity: 243,464

Program Performance (fiscal year 2017 dollars in millions)

	As of 05/2004	Latest 12/2015	Percent change
Research and development cost	$590.9	$1,434.3	142.8%
Procurement cost	$10,297.3	$8,129.4	-21.1%
Total program cost	$10,888.2	$9,563.7	-12.2%
Program unit cost	$.033	$.035	6.4%
Total quantities	328,674	271,202	-17.5%
Acquisition cycle time (months)	85	124	45.9%

The JTRS HMS program has demonstrated that its critical technologies are mature, and program officials report currently stable designs for both the Rifleman and Manpack radio systems. Developmental and operational testing in recent years identified deficiencies affecting both radio systems, which program officials report have since been resolved. However, the Army has not yet fully verified the resolution of these issues, or the operability of both radios, through operational testing. According to officials, the JTRS HMS program will conduct manufacturing readiness assessments for both the Rifleman and Manpack radios as part of separate full rate production decisions scheduled in 2018 and 2019, respectively. Initial fielding of the Navy's Mobile User Objective System (MUOS) waveform in some radios is delayed while the Navy corrects deficiencies it identified in operational testing.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	○	○
• Test a production-representative prototype	●	●

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

JTRS HMS Program

Technology and Design Maturity

At the JTRS HMS program's development start in 2004, the program did not assess the maturity of its critical technologies—an approach inconsistent with best practices. Further, the program had not fully matured all of its critical technologies by its 2011 production start. Instead, the program completed development of individual critical technologies in May 2015. The program assessed both radio designs as stable at critical design review in 2008, but now forecasts new design changes that could undermine this stability.

In fiscal year 2014, developmental testing of the Manpack radio identified deficiencies with the system's reliability. Initial operational testing that same year flagged suitability shortfalls, specifically related to excessive weight of the Manpack units. Similarly, operational testing of the Rifleman radio in fiscal year 2014 identified suitability problems related to overheating and rapid battery depletion. Program officials stated that the contractor has redesigned both radio systems to resolve these various problems. However, the Army has not yet completed operational testing to ensure that all deficiencies have been addressed.

Production Maturity

According to JTRS HMS program officials, the program conducted manufacturing readiness assessments for the Rifleman radio system and intends to evaluate the results in advance of that system's full rate production decision in April 2018. They also stated that the JTRS HMS program will conduct manufacturing readiness assessments for the Manpack radio as part of its separate full rate production decision in May 2019. However, the program office has not yet conducted or scheduled these assessments, citing anticipated design changes.

Other Program Issues

At present, use of the MUOS waveform—on which some Manpack radios will rely—is largely unavailable to the warfighter because of delays with authorizing its use in an operational environment. Although the program has not identified MUOS as a critical technology, without this waveform, affected Manpack radios are only able to communicate through legacy communications capabilities. Officials stated that the authorization delay would not impact the time frame for the fielding of Manpack radios but would affect the level of MUOS availability in the field. The Navy conducted initial operational testing of the MUOS waveform in October and November 2015. Based on those results, the Navy has programmed additional work to correct deficiencies along with an additional round of operational testing. The Army plans to leverage this operational testing to inform future fielding decisions. According to program officials, changes to the Manpack radios, necessary for implementation of MUOS, required the program to extend software development. JTRS HMS has successfully completed the initial set of MUOS conformance tests but will have to complete additional conformance tests in order to be fully certified for use in the field.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate. The program office also disagreed with our characterization of past testing outcomes identified in this assessment.

GAO Response

Our characterization of past JTRS HMS testing outcomes is derived directly from reports issued by the program's testing authorities within DOD.

M109A7 Family of Vehicles (M109A7 FOV)

The Army's M109A7 FOV system consists of two individual vehicles, a self-propelled howitzer (SPH), and a tracked ammunition carrier that provides operational support. The SPH is a tracked, aluminum armored vehicle armed with a 155 millimeter cannon. The M109A7 FOV is expected to provide improved sustainability over the current howitzer fleet through the incorporation of a newly designed hull; modified M2 Bradley infantry fighting vehicle power train, suspension system, and track; and a modernized electrical system.

Source: U.S. Army.

Program Essentials

Prime contractor: BAE Systems Land & Armament L.P.
Program office: Warren, MI
Funding needed to complete:
  R&D: $46.2 million
  Procurement: $5,384.8 million
  Total funding: $5,431.0 million
  Procurement quantity: 503

Program Performance (fiscal year 2017 dollars in millions)

	As of 02/2012	Latest 12/2015	Percent change
Research and development cost	$1,093.3	$1,149.5	5.1%
Procurement cost	$6,160.7	$6,255.2	1.5%
Total program cost	$7,254.0	$7,404.7	2.1%
Program unit cost	$12.464	$12.991	4.2%
Total quantities	582	570	-2.1%
Acquisition cycle time (months)	118	120	1.7%

The M109A7 FOV program entered low-rate initial production in October 2013 with its two critical technologies mature and design stable. However, the program now plans costly retrofits to the first 67 vehicles to improve their transmission systems and, for the howitzers, their cannon tubes. To date, the program has not demonstrated that its manufacturing processes are in statistical control, almost 3 years after production began. The program's schedule also hinges on completing developmental and operational testing with few, if any, additional technical discoveries. In the event that remaining testing identifies new deficiencies requiring design changes or additional retrofitting, the program will likely incur cost increases and capability delays.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▪▪▪▪	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▪▪▪▪	●
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▪▪▪▪	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	○	○
• Test a production-representative prototype	○	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

M109A7 FOV Program

Technology and Design Maturity

The M109A7 FOV program's two critical technologies—power pack integration and the ceramic bearing of the generator assembly—have been assessed as fully mature. According to program officials, the design is currently stable with all of the expected drawings released and a system-level integrated prototype demonstrated. Despite this, a program official indicated that the current M109A7 transmission will be replaced by a more efficient transmission in fiscal year 2019, resulting in retrofits to all 67 low-rate production vehicles. The program official also stated that the SPH's current steel cannon tube will be replaced with a chrome-plated design in order to better meet its required service life. This retrofit began in January 2016 and the program is planning for 611 cannon tube upgrades in total.

Production Maturity

The program started low-rate initial production in October 2013, and the first vehicle was delivered in March 2015. To assess its production maturity, the program compares totals for expected and actual manufacturing hours to assess efficiency gains over time. To date, the program has not demonstrated statistical control of its critical manufacturing processes. Our best practices work has shown that if a program's critical manufacturing processes are not demonstrated and in control before production begins, it is at risk of increased cost and schedule delays. Additionally, quality control issues with the engine forced the program to adjust the test schedule. For example, some vehicles overheated. However, the program determined the root cause for the overheating and is making the necessary corrections.

Other Program Issues

The program's current schedule is predicated on completing remaining developmental testing and initial operational test and evaluation (IOT&E) with few, if any, new discoveries of technical deficiencies. The M109A7 FOV's IOT&E was originally planned for June 2016 has now been further delayed until the second quarter of fiscal year 2018, due to problems associated with soldiers being exposed to toxic fumes during a test event in October 2016. Root-cause analysis indicated a combination of breech malfunctions, improper crew procedures, and improper maintenance caused toxic fumes in certain guns to rise to dangerous levels. The program has addressed hardware issues and added additional training, to address the factors that led to this dangerous situation. The low-rate initial production is now being extended through fiscal year 2017 and the full-rate production decision was planned for December 2017 is now scheduled for June 2018. Additional schedule delays and cost increases could result if additional deficiencies are found during IOT&E that affect the M109A7 FOV's ability to be found operationally effective and suitable and, subsequently, require design changes or retrofits. For example, based on previous developmental testing results, program officials redesigned howitzer hardware and software to improve maximum rate of fire performance.

Program Office Comments

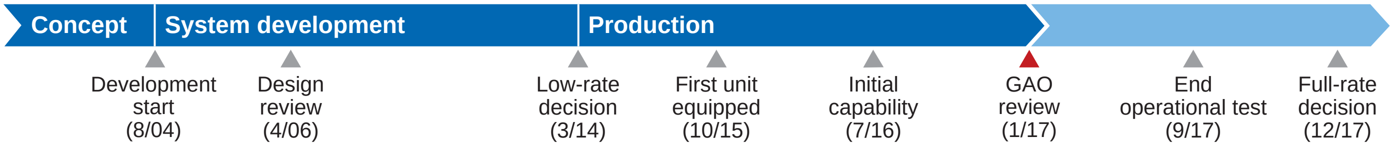
In commenting on a draft of this assessment , the program office provided technical comments, which were incorporated where deemed appropriate.

Lead Component: Army | Common Name: PAC-3 MSE

Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)

The Army's PAC-3 MSE is a surface-to-air missile designed to defeat tactical ballistic missiles and other aerial threats. The MSE is the latest version of PAC-3 missiles integrated into the PATRIOT system, which includes radars, launchers, and a command and control system. The PAC-3 MSE improves upon earlier PAC-3 variants and is expected to provide a more lethal interceptor with expanded range and accuracy against complex threats.

Source: U.S. Army.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Redstone Arsenal, AL
Funding needed to complete:
  R&D: $0.0 million
  Procurement: $3,875.3 million
  Total funding: $3,884.9 million
  Procurement quantity: 813

Program Performance (fiscal year 2017 dollars in millions)

	As of 08/2004	Latest 10/2016	Percent change
Research and development cost	$585.6	$971.6	65.9%
Procurement cost	$7,318.9	$5,556.6	-24.1%
Total program cost	$7,904.6	$6,537.8	-17.3%
Program unit cost	$5.173	$5.811	12.3%
Total quantities	1,528	1,125	-26.4%
Acquisition cycle time (months)	NA	143	NA

Table note: Change in acquisition cycle time could not be calculated as initial estimates did not include an initial operational capability date.

The PAC-3 MSE program entered production in 2014 with mature technologies and a stable design. Two years after production start, the program successfully demonstrated its manufacturing processes were under control. The program achieved initial operational capability in 2016 ahead of schedule, which program officials attribute to early missile deliveries and training efficiencies. The Army has also successfully completed three flight tests of the missile during developmental testing for various PATRIOT system software and hardware upgrades. While the program has made some progress finalizing the terms of its 2015 missile production undefinitized contract action, the Army does not expect to complete this process until nearly a year and a half after the issuance of the action, which may place the program at risk of cost growth.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained ▨ Not applicable

PAC-3 MSE Program

Technology and Design Maturity

The PAC-3 MSE program entered production in March 2014 with a stable design and all four of its critical technologies mature. Although the PAC-3 MSE has components that are 90 percent common with an earlier PAC-3 variant, four unique technologies required development—a dual pulse solid rocket motor, thermal batteries, an ignition safety device, and insensitive munitions to prevent inadvertent launch or detonation.

Production Maturity

The PAC-3 MSE program has demonstrated its manufacturing processes are in control. However, this demonstration did not occur until over 2 years after production start, which is inconsistent with best practices. PAC-3 MSE began production in March 2014 by demonstrating that all materials, manpower, tooling, and facilities were proven on a pilot production line and were available to meet the low rate production schedule, as recommended by DOD guidance. However, according to best practices, programs should demonstrate manufacturing processes to be in statistical control prior to production start. Specifically, critical processes should be repeatable, sustainable, and consistently producing parts within the quality standards.

Other Program Issues

The PAC-3 MSE program achieved initial operational capability in July 2016—about 5 months ahead of schedule—by equipping a PATRIOT battalion with 48 missiles. Program officials attributed the early completion of this milestone to faster than expected missile deliveries from the prime contractor and synergies with existing training for PATRIOT battalions.

In 2016, the program successfully completed three flight tests for the PAC-3 MSE during developmental testing for various PATRIOT system software and hardware upgrades. The PATRIOT system required these upgrades to fully test and utilize the missile's capabilities. Future results from system-level operational testing of the missile with these upgrades, which began in fiscal year 2016, will be used to support a PAC-3 MSE full-rate production decision, which is currently planned for 2017.

The PAC-3 MSE program continues to encounter delays in definitizing its production undefinitized contract actions. Last year, we reported that completion of the final contract pricing and terms for the program's 2014 production contract was delayed over a year beyond its expected date. We previously reported delays in finalizing this type of contract places the program at risk of cost growth as the government normally reimburses contractors for all allowable costs incurred during the undefinitized period, giving contractors little incentive to control costs. The program is also facing delays in finalizing terms for its 2015 production contract. Although the program made some progress by determining nearly 85 percent of the contract terms within 180 days, officials do not expect to fully complete this process until December 2016—nearly a year and a half after the issuance of the action.

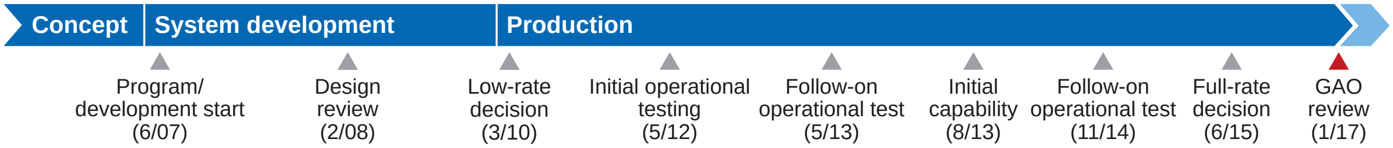
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where appropriate.

Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)

WIN-T is the Army's high-speed and high-capacity tactical communications network. It connects units with higher levels of command and is being fielded in three increments. The Army completed fielding of the first increment in 2012 and ended the development of the third increment in 2016. Together, those increments provided data, voice, and video networking capability, along with critical software upgrades. The Army expects the second increment, Increment 2, to provide required networking on-the-move capability. We assessed Increment 2.

Source: U. S. Army.



Program Essentials

Prime contractor: General Dynamics C4 Systems, Inc.
Program office: Aberdeen Proving Ground, MD
Funding needed to complete:
- R&D: $44.2 million
- Procurement: $7,525.0 million
- Total funding: $7,569.2 million
- Procurement quantity: 2,137

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2007	Latest 09/2016	Percent change
Research and development cost	$258.8	$334.8	29.4%
Procurement cost	$3,763.4	$10,875.1	189.0%
Total program cost	$4,022.2	$11,209.9	178.7%
Program unit cost	$2.125	$3.005	41.4%
Total quantities	1,893	3,730	97.0%
Acquisition cycle time (months)	50	74	48.0%

WIN-T Increment 2 entered production in March 2010 with its critical technologies mature. The program does not track the metric we use to measure design stability as WIN-T is primarily an information technology integration effort. Instead, design performance is measured through testing designed to demonstrate performance at increasing levels of system integration. The program has met its revised reliability criteria and has improved its cyber-defense capabilities. In January 2015, the Army reported that the program had breached a statutory unit cost growth threshold. Program officials stated that they are undertaking steps to reduce future unit costs below this threshold level.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▪▪▪▪	▪▪▪▪
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	○	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

WIN-T Inc 2 Program

Technology, Design, and Production Maturity

WIN-T Increment 2 entered development in June 2007 with 15 critical technologies. Of these, 3 were mature, 4 were approaching maturity, and 8 were immature or not assessed at development start. By the program's March 2010 production start, all 15 critical technologies were mature. The program does not track the metric we use to measure design stability—the number of releasable drawings—as WIN-T is primarily an information technology integration effort. Instead, design performance is measured through a series of tests designed to demonstrate performance at increasing levels of system integration. The program began testing a production representative prototype in March 2011 and assessed that its manufacturing processes were within statistical control in 2012, both after production began.

Other Program Issues

The program made progress against performance and reliability objectives—issues evident during earlier rounds of operational testing. This was achieved, in part, due to a relaxing of the reliability objectives as part of an update to the program's capability production document. The prior operational reliability standard of 90 percent—or probability of mission success without an essential functional failure—was deemed "excessively high when compared to predecessor, current, and analogous systems during similar periods in their respective life cycles." The operational reliability threshold was revised to 80 percent, and the program met this threshold during prior testing.

While the program continues to carry a high risk regarding its defensive capabilities against cyber-attacks, it is also making progress in mitigating these deficiencies. According to program officials, in order to reduce this risk, the program is consistently updating its cyber defenses, testing them against both internal and independent third-party attack teams, and then refining its cyber defenses based on the results. For example, the program is working with an independent team at Johns Hopkins University that attempts to hack the program's system and must also defend against other U.S. Army cyber attackers as part of the program's network integration tests. Program officials stated that since fiscal year 2015, the program has improved its cyber defenses, but expects to continue to improve over time and reduce the risk level. However, officials also noted that given the nature of cyber-attacks and cyber defense, the risk would likely remain throughout the life of the program as an issue that will always need attention.

The program continues to track cost growth as a concern following the January 2015 announcement that the program had breached a statutory significant unit cost threshold. Program officials stated that the program continues to reduce unit costs, which should bring down average unit costs over time. In addition, officials stated that the program is working to reduce costs further by decreasing the complexity of the hardware—both in terms of size and number of components—and by employing better buying power initiatives. With these efforts, officials are targeting further reduced costs in the future.

Program Office Comments

Program officials stated that WIN-T is currently fielded to 14 Brigade Combat Teams, 7 Division Headquarters, and the U.S. Army Signal School, Fort Gordon, GA. Officials noted the program remains on track to field additional units as directed by the Army at a rate of approximately two per year. Officials also reported the program continues to use soldier feedback from theater and test results to improve WIN-T Increment 2 capabilities with the primary focus being on simplifying the operations and maintenance of the equipment. Finally, officials reported the program office has developed new vehicle-based capabilities to meet emerging Army expeditionary and transportability needs and will test these capabilities at an integration test event in summer 2017.

Improved Turbine Engine Program (ITEP)

The Army’s Improved Turbine Engine Program (ITEP) is developing a replacement engine for the Black Hawk and Apache helicopter fleets. The new engine is designed for increased power, performance, and fuel efficiency; enhanced reliability; increased service life; and a lower maintenance burden. The Army plans to begin fielding these engines in fiscal year 2026.

Source: U.S. Army

Current Status

In August 2016, the Assistant Secretary of the Army, for Acquisition, Logistics, and Technology, approved ITEP’s entry into the technology maturation and risk reduction phase. The Army awarded two fixed-price incentive (firm target) technology maturation and risk reduction contracts totaling $254.7.million to General Electric and Advanced Turbine Engine Corporation with the goals of planning, designing, and developing the engine through the preliminary design review. Each contractor will hold a separate preliminary design review in the second quarter of fiscal year 2018 prior to entry into system development. The Army intends to award a cost-plus-incentive-fee contract for system development with competition limited to the two contractors awarded preliminary design contracts.

An initial technology readiness assessment completed in October 2014 identified three critical technologies—advanced inlet particle separator, compressor/advanced aerodynamics, and hybrid bearings—as approaching full maturity. A second assessment in support of system development start, planned for January 2017, will provide updated information on each contractor’s critical technologies.

In 2015, Sikorsky Aircraft Corporation and Boeing initiated trade studies to evaluate potential approaches for integrating ITEP hardware, electrical systems, and software into Black Hawk and Apache helicopter airframes. The Army is investing approximately $24.4 million to complete these trade studies and plans to rely on them to define a system integration approach that balances cost and schedule considerations, and required airframe modifications and component constraints. According to the program office, the trade studies will also identify system integration risks and facilitate development of mitigation strategies prior to the start of system development.

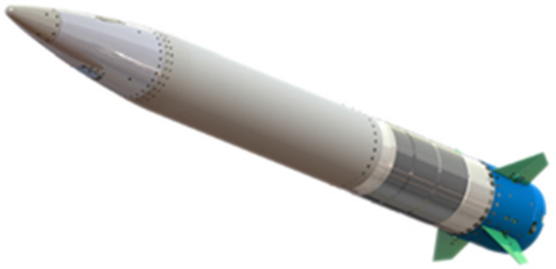
Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: $10,445.89 million
Research and development: $2,417.79 million
Procurement: $8,028.10 million
Quantity: 74 (development), 6,215 (procurement)

Next Major Program Event: System development start, third quarter fiscal year 2018

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Long Range Precision Fires (LRPF)

Long Range Precision Fires (LRPF) are part of a family of ballistic missiles designed to attack area and point targets to ranges of 300 kilometers and beyond. Each LRPF launch pod missile container is intended to hold a minimum of one and up to four missiles. LRPF is compatible with existing M142 and M270 rocket launch Systems. LRPF is intended to replace the Army Tactical Missile System (ATACMS) and comply with statutory requirements for insensitive munitions and DOD policy on cluster munitions.



Source: U.S. Army

Current Status

LRPF is scheduled to enter technology development in January 2017. Originally scheduled for January 2016, program officials told us this year-long delay follows a review of the analysis of alternatives and reconsideration of the LRPF range requirement and launch pod capacity. LRPF program officials maintain this will not affect the overall program schedule as long as technology development begins by March 2017. The start of system development was delayed from 2020 to 2021.

The Army has identified two critical technologies for LRPF—the rocket motor and warhead. The Army is relying on these two technologies to provide capabilities that allow LRPF to meet its minimum range requirement and limit unexploded ordnance to levels compliant with DOD's policy on cluster munitions, respectively. The program recently increased the number of test missiles it plans to procure from 6 to 8 during technology development, and 40 during system development. The LRPF program has an approved test and evaluation master plan. An independent cost estimate, which will inform the decision to enter technology development, is under development.

LRPF will employ competitive prototyping prior to the start of system development. In 2016, the Army awarded cost-plus-fixed-fee contracts to Lockheed Martin and Raytheon to begin developing LRPF missile designs. This work will inform the program's technology readiness assessment, which it plans to complete prior to system development. Program officials expect to select a single contractor to execute LRPF system development.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):

Total program: $2,901.4 million
Research and development: $771.7 million
Procurement: $2,129.7 million
Quantity: 48 (development), 2,422 (procurement)

Next Major Program Event: Start of technology development, January 2017

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

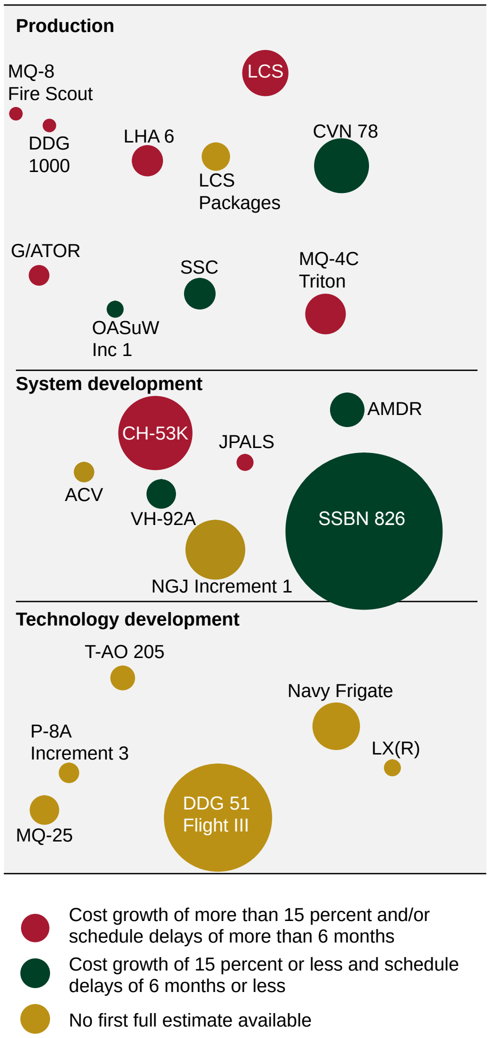
Navy and U.S. Marine Corps Service Summary

We completed individual assessments on 23 of the Navy and Marine Corps' 41 current and future major defense acquisition programs. Of these 23 programs, 17 are, for the most part, in system development or early production; 3 are future programs DOD expects to enter system development in the next few years; 2 are programs that are well into production, but planning to introduce new increments of capability; and 1 is the Navy's Frigate initiative, which is currently part of the Navy's Littoral Combat Ship (LCS) program, but is expected to be restructured into its own separate program soon. We found the Navy and Marine Corps currently estimate a need of $236 billion in funding to complete the acquisition of these 23 programs. In addition, we compared these 23 programs' first full estimates of cost and schedule, as available, with their current estimates and found:

- net cost growth totals approximately $24 billion, all of which occurred more than 5 years ago, and
- program schedule delays average 35 months.

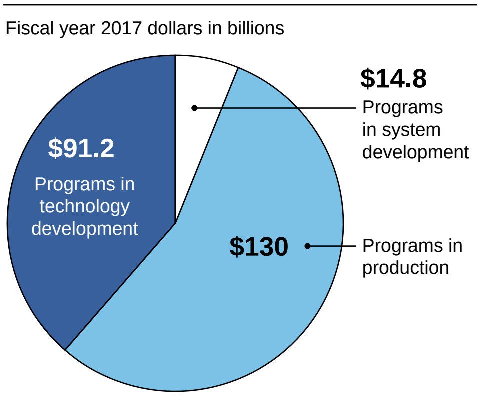
Further, 1 of the 23 programs—LHA 6 America Class Amphibious Assault Ship—completed all the activities associated with the applicable knowledge based best practices we assess, although these activities were not fully complete at the time the program reached these key knowledge points.

Acquisition Phase and Size of the 23 Programs Assessed

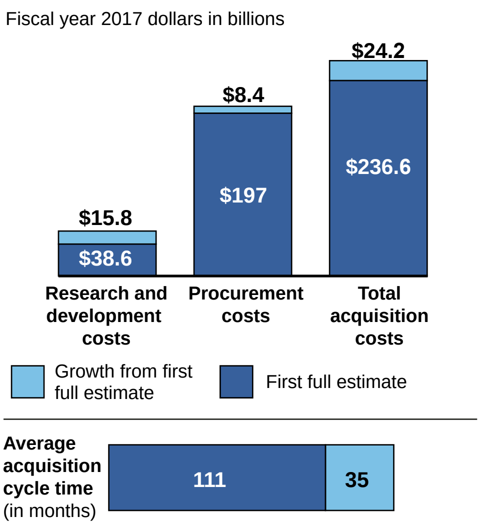


Note: Bubble size is based on each program's currently estimated future funding needed.

Currently Estimated Acquisition Cost for the 23 Programs Assessed



Cost and Schedule Growth on 14 Programs in the Current Portfolio



Note: For acquisition cycle time only 13 programs were assessed as not all programs contained sufficient information within their first full estimates to determine acquisition cycle time. In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match At KP1	Current Status	Knowledge Point 2 Product design is stable At KP2	Current Status	Knowledge Point 3 Manufacturing processes are mature At KP3	Current Status
ACV	○	●	○	○	KP 3 in future	
AMDR	○	○	○	●	KP 3 in future	
CH-53K	○	○	○	- - -	KP 3 in future	
CVN 78	○	○	○	●	▨	
DDG 1000	○	○	○	●	▨	
G/ATOR	- - -	●	○	●	○	○
JPALS	○	○	○	●	KP 3 in future	
LHA 6	●	●	○	●	▨	
LCS	○	○	○	●	▨	
LCS Packages	○	○	- - -	●	▨	
MQ-4C Triton	○	●	○	●	○	○
MQ-8 Fire Scout	- - - - - -		○	●	- - - - - -	
NGJ Inc 1	○	○	KP 2 in future		KP 3 in future	
OASuW Inc 1	○	●	○	○	○	○
SSBN 826	○	○	KP 2 in future		▨	
SSC	●	●	○	○	○	○
VH-92A	○	●	○	○	KP 3 in future	

● All applicable knowledge practices completed

○ One or more applicable knowledge practices were not completed

▨ Knowledge practice is not applicable

- - - Information not available for knowledge practice

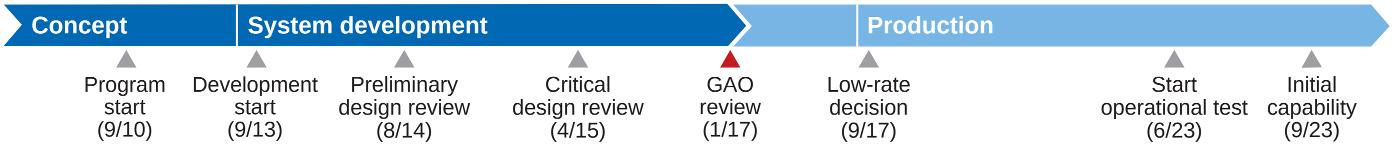
Source: GAO analysis of DOD data. | GAO-17-333SP

Navy and Marine Corps Program Assessments

Air and Missile Defense Radar (AMDR)

The Navy's AMDR is a next-generation radar program supporting surface warfare and integrated air and missile defense. AMDR is developing an S-band radar—known as SPY-6—that is expected to have increased sensitivity for long-range detection to improve ballistic missile defense against advanced threats. The program is also developing a radar suite controller to provide radar resource management and coordination, and to interface with an upgraded Aegis combat system to provide integrated air and missile defense for DDG 51 Flight III destroyers.


Source: © 2015 Raytheon Company.



Program Essentials

Prime contractor: Raytheon
Program office: Washington, DC
Funding needed to complete:
R&D: $468.7 million
Procurement: $3,191.6 million
Total funding: $3,660.2 million
Procurement quantity: 22

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2013	Latest 12/2015	Percent change
Research and development cost	$1,966.4	$1,955.2	-0.6%
Procurement cost	$4,066.9	$3,440.2	-15.4%
Total program cost	$6,063.7	$5,425.6	-10.5%
Program unit cost	$275.625	$246.619	-10.5%
Total quantities	22	22	0.0%
Acquisition cycle time (months)	155	155	0.0%

AMDR completed its critical design review in April 2015 with four critical technologies nearing maturity and its design stable. The program has largely completed its four planned software builds, with the last build's completion expected by April 2017. In June 2016, a full-scale, production-representative SPY-6 radar array was installed at the Navy's Pacific Missile Range Facility for land-based testing. Testing of the radar system at sea is not planned until 2020, and initial operational test and evaluation is expected in 2023. The program's test and evaluation master plan remains unapproved by DOD's Director, Operational Test and Evaluation (DOT&E) due to concerns that the Navy's proposed testing approach would not perform testing under realistic operational conditions. The test plan may not be approved before the AMDR low-rate initial production decision in September 2017.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

AMDR Program

Technology Maturity

AMDR's four critical technologies—digital beamforming, transmit/receive modules, multi-mission scheduling and discrimination software, and distributed receivers/exciters—are nearing maturity. The program is expected to deliver its first radar for installation on the lead DDG 51 Flight III ship in early 2020. To support initial integration between the radar and the combat system, the AMDR contractor developed and delivered SPY-6 simulator and emulator capabilities to help inform the program's knowledge of the radar and Aegis combat system interface performance prior to a 6-month risk reduction test period planned for the second half of fiscal year 2017. Additionally, the contractor built and tested a full-scale, single-face, 14-foot S-band radar array. In June 2016, this production-representative array was delivered and installed at the Navy's Pacific Missile Range Facility in Hawaii for live testing in a more representative environment. This testing is expected to reduce technical risk for the radar and help inform a low-rate initial production decision in September 2017.

The AMDR program's software has been developed in four builds using an approach that includes upfront requirements and architecture analysis for each build, as well as continuous integration of new software and automated testing to ensure functionality and performance. This includes aligning software features to test events to ensure timely software completion and delivery to support dry runs and tests. The first two builds developed basic infrastructure, anti-air warfare, and ballistic missile defense capabilities. The third and fourth provide the full extent of radar capabilities, including debris detection and mitigation and advanced discrimination of missile threats. As of December 2016, the fourth build was 80 percent complete, with completion planned by April 2017—about half a year later than previously planned. The Navy also plans to upgrade the combat system for integration with the SPY-6 radar, which will require significant software development for the interface between the radar and the combat management system. These software builds are expected to be completed in fiscal year 2021.

Design and Production Maturity

In April 2015, the program office completed a critical design review, with 100 percent of design drawings finalized. The design has remained stable as the program moves toward its initial production decision. However, because the decision to begin low-rate initial production will be made prior to demonstrating technology maturity at sea and before combat system integration and test, design stability remains a risk. Any design issues identified through testing the radar at sea and with the combat system will need to be addressed during SPY-6 production. The program office identified four key product characteristics that will be closely monitored during manufacturing. The characteristics are associated with the structural features of the radar and elements of the transmit/receive modules and beamforming technologies.

Other Program Issues

In 2013, DOT&E disapproved AMDR's test and evaluation master plan due to concerns the Navy's proposed testing approach would not provide realistic operational conditions. A senior DOT&E official noted the concern that the Navy has not involved DOT&E in efforts to update the test plan and anticipates that, without DOT&E involvement, the plan is likely to remain unapproved by DOT&E when the program reaches its September 2017 production decision.

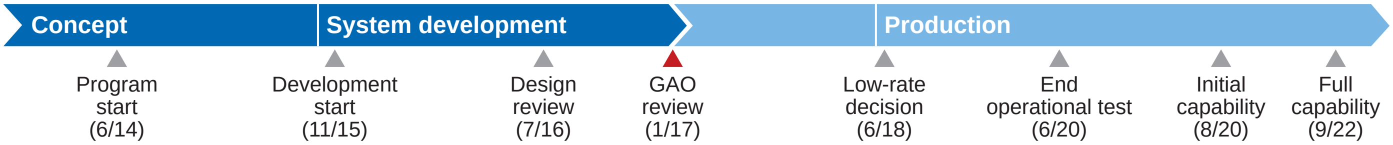
Program Office Comments

In commenting on a draft of this assessment, the program office stated the SPY-6 testing it completed at the Pacific Missile Range Facility validated the system performance previously measured in testing at the contractor’s facility, allowing the program to procure long lead material for the first DDG 51 Flight III in December 2016. Upcoming live testing of several systems is expected to demonstrate the advanced features and unprecedented capability of this radar. The program reports being on track to provide this much-needed capability to the warfighter.

Amphibious Combat Vehicle (ACV)

The Marine Corps' ACV is the successor program to the canceled Expeditionary Fighting Vehicle (EFV). The ACV is intended to transport Marines from ship to shore and provide improved mobility and high levels of protection. The acquisition approach calls for three increments of development (1.1, 1.2, and 2.0) and leverages work accomplished under the EFV program. The Marine Corps expects later ACV increments to have improved amphibious capability over the first increment, ACV Increment 1.1. We assessed ACV Increment 1.1.

Source: U.S. Marine Corps.



Program Essentials

Prime contractor: BAE Systems Land & Armaments LP, Science Applications International Corporation
Program office: Stafford, VA
Funding needed to complete:
R&D: $382.0 million
Procurement: $1,057.8 million
Total funding: $1,477.7 million
Procurement quantity: 204

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 08/2016	Percent change
Research and development cost	NA	$796.3	NA
Procurement cost	NA	$1,057.8	NA
Total program cost	NA	$1,903.4	NA
Program unit cost	NA	$7.931	NA
Total quantities	NA	240	NA
Acquisition cycle time (months)	NA	57	NA

The ACV program completed a combined preliminary/critical design review in October 2016 with mature critical technologies and stable designs from its two contractor teams. The program includes two critical technologies, one of which is currently in use on an existing platform. The other technology, the Remote Weapon Station, completed testing in June 2016, demonstrating it can operate in a marine environment. According to the program office, both contractors released 90 percent of their drawings at the design review and are developing prototypes. The program schedule includes concurrent testing and production that place ACV at risk for costly retrofits as knowledge is gained in testing. Plans are in place for corrective action periods to implement modifications stemming from system-level developmental testing. The Marine Corps plans to select a single vendor in 2018 to produce the ACV.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

ACV Program

Technology Maturity

ACV entered system development in 2015 with one mature critical technology and another critical technology approaching maturity. The program now assesses both technologies as fully mature. One technology, the Driver's Vision Enhancement, assists the ACV driver in safely operating the vehicle with a closed hatch during both the day and night and is currently used on the Assault Amphibious Vehicle. The other critical technology, the Remote Weapon Station (RWS), is a stabilized, remote operated, weapon station designed to operate in the maritime environment. The RWS is government-furnished equipment that will be integrated into the ACV by the contractor and is a version of a similar system developed for the Navy's Mark VI Patrol Boat. RWS successfully completed water tank drop testing in June 2016.

Design Maturity

According to the program office, the two ACV contractors released 90 percent of their drawings at the time of the combined preliminary/critical design review in October 2016. Each contractor is expected to provide a vehicle hull that will accommodate a minimum crew of three along with 10 combat equipped Marines. Both contractors are now developing prototypes of their designs, each using some form of a "V" hull design for added force protection from underside blasts and improved seats to protect occupants. The Marine Corps expects prototype delivery ahead of the contractual due date of March 2017.

ACV Increment 1.1 units will rely on connector vessels to transport them from amphibious ships to the shore. The Marine Corps anticipates ACV Increment 1.2 will be capable of self-deploying to shore. According to program officials, the ACV contractor teams designed Increment 1.1 vehicles with sufficient growth margins to accomodate the requirements of Increment 1.2. The Marine Corps is also investing in studies that could lead to a high water speed vehicle for ACV Increment 2.0.

Production Maturity

The ACV program's schedule includes concurrent testing and production activities that could leave the program with little flexibility to correct deficiencies identified during developmental testing and result in costly retrofits. The Marine Corps plans to select a single vendor in 2018 to produce the ACV, whereas system-level developmental testing is not expected to complete until December 2019, approximately one and a half years after production start. The program office has plans for a corrective action period for the first lot and potentially second lot of low-rate production vehicles to implement any remaining modifications resulting from developmental testing. According to the program office, the Marine Corps already budgeted for these potential retrofits. Program officials reported they plan to demonstrate critical manufacturing processes on a pilot production line prior to entering production and that low-rate production quantities comprise more than 10 percent of the total ACV Increment 1.1 production quantity, but attributed this decision to ensuring an efficient ramp up to full-rate production.

Other Program Issues

Contract performance was delayed due to a bid protest filed with GAO, which was denied in March 2016. According to the program office, the bid protest pushed the expected production decision out to the third quarter of fiscal year 2018. In the fiscal year 2017 budget, the Marine Corps funded ACV Increment 1.1 to the level identified in the program's independent cost estimate.

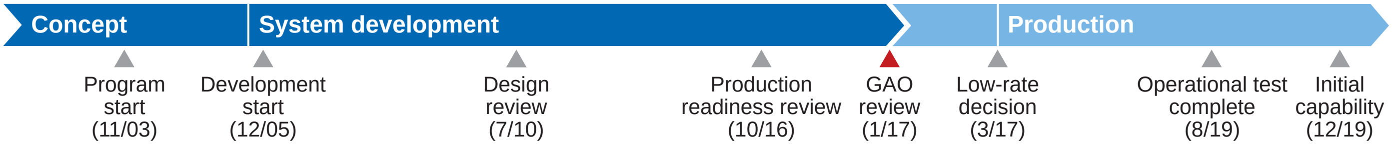
Program Office Comments

In commenting on a draft of this assessment, the program office stated that, although the ACV program leverages previous EFV program work, it predominantly utilized the Marine Personnel Carrier technology demonstrator and prototype demonstration efforts to inform ACV requirements. Program officials also noted program funding is depicted in base year fiscal year 2017 dollars, making costs appear greater than if presented in the program's base year fiscal year 2014 dollars. Program officials further noted that "Program unit cost" depicts Program Acquisition Unit Cost, not Average Procurement Unit Cost (APUC). The program unit cost value includes military construction funding and acquisition operations and maintenance funding, which are not included in APUC.

CH-53K Heavy Lift Replacement Helicopter (CH-53K)

The Marine Corps' CH-53K heavy-lift helicopter is intended to transport armored vehicles, equipment, and personnel to support operations deep inland from a sea-based center of operations. The CH-53K is expected to replace the legacy CH-53E helicopter and provide increased range and payload, survivability and force protection, reliability and maintainability, and coordination with other assets, while reducing total ownership costs.

Source: Sikorsky Aircraft Corporation.



Program Essentials

Prime contractor: Sikorsky Aircraft Corporation
Program office: Patuxent River, MD
Funding needed to complete:
- R&D: $1,130.2 million
- Procurement: $19,232.3 million
- Total funding: $20,388.0 million
- Procurement quantity: 194

Program Performance (fiscal year 2017 dollars in millions)

	As of 12/2005	Latest 08/2016	Percent change
Research and development cost	$4,749.5	$6,936.7	46.1%
Procurement cost	$13,208.9	$19,273.1	45.9%
Total program cost	$17,958.4	$26,251.9	46.2%
Program unit cost	$115.118	$131.259	14.0%
Total quantities	156	200	28.2%
Acquisition cycle time (months)	119	168	41.2%

CH-53K critical technologies are approaching maturity and the program is completing flight tests to demonstrate recent redesigns to key components. These redesigns, which follow the program's July 2010 critical design review, have delayed aircraft assembly and testing and slowed delivery of test aircraft. As a result, the program has delayed its entry into low-rate initial production until March 31, 2017. The program also faces uncertainty associated with the relocation of the CH-53K production facility, and officials report they continue to assess potential impacts. The program has also accepted delivery of its four test aircraft and, as of January 2017, has completed over 370 flight test hours.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	▪▪▪▪
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

CH-53K Program

Technology and Design Maturity

The CH-53K program entered system development in December 2005 with immature critical technologies—an approach inconsistent with best practices. These technologies, which include the main rotor blade and main gear box, were approaching maturity at the program's critical design review (CDR) in July 2010. The program began flight testing both of the technologies in October 2015. Although this testing constitutes an operational environment, the technologies have not yet been assessed for final form, fit, and function.

At CDR, the program assessed what was later proven to be an unstable design. The extent of this instability is unknown, however, as the program no longer tracks information on design drawings. Unanticipated design changes to non-critical technology components after CDR caused test and production delays. We previously found that components within the rear module assembly, part of the main gear box, required a number of redesigns. For example, we found equipment holding one of the gears in place failed, which required a reconfiguration of the rear module assembly retention design. The contractor completed and installed the new design on each of the five test aircraft. Program officials reported that since the redesign, the program has successfully tested the main gear box, and actions are underway to mitigate the remaining design risks in the program. The program estimates the CH-53K will not only meet, but will exceed all of its key performance requirements.

Production Maturity

To date, the CH-53K program has taken delivery of five test vehicles, which includes the ground test vehicle and four flight test aircraft. All four aircraft were modified to include the redesigned main gear box and have entered flight testing—accumulating over 370 flight test hours, as of January 2017. However, delays producing test articles have slowed the overall schedule. As a result, the program postponed its low-rate initial production decision to March 31, 2017. This delay exceeded the program’s schedule parameters, which required the Marine Corps to report the delay to the Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L). USD AT&L subsequently approved a schedule extension and decided not to require the program to establish a new acquisition program baseline until the CH-53K's low-rate production decision is reached. Our best practices work has shown that if a program's critical manufacturing processes are not demonstrated and in control before production begins, it is at risk of increased cost and schedule. The program is nearing its expected low-rate production decision on March 31, 2017, and does not have all of its critical manufacturing processes under statistical control, nor has its manufacturing readiness level been assessed at DOD's recommended level for starting production.

According to program officials, production will be moved from its current location in West Palm Beach, Florida, to Sikorsky’s headquarters, which is located in Stratford, Connecticut. According to officials, the current location in West Palm Beach is owned by United Technologies—Sikorsky’s prior owner—and Lockheed Martin’s acquisition of Sikorsky necessitated the change. The move will require a number of equipment and configuration changes to Sikorsky’s Stratford facility, which will take time to complete and pose risk to the CH-53K production schedule. Program officials continue to assess the potential impacts of the production relocation.

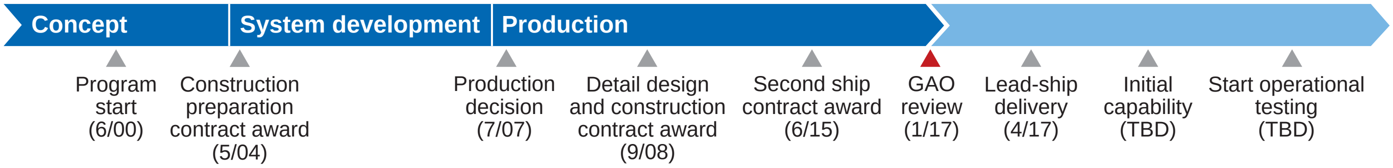
Program Office Comments

In commenting on a draft of this assessment, the program office concurred with the contents, but provided additional information. While the program's production readiness was assessed as below DOD's required level for production, the program expects to meet DOD's recommended standard upon successful completion of initial operational test and evaluation. In addition, the program office stated the movement of the production facility was driven by required capacity and not the Lockheed Martin acquisition. The program is monitoring the contractor's move plans, which just competed the second of six gates. There is a planned gap of 8 months between the completion of the fourth and fifth system demonstration test articles in order to facilitate the final assembly move. The program also provided other technical comments, which were incorporated where deemed appropriate.

CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)

The Navy developed the Ford-class nuclear-powered aircraft carrier to introduce new propulsion, aircraft launch and recovery, and survivability capabilities to the carrier fleet. The Ford-class is the successor to the Nimitz-class aircraft carrier, and its new technologies are intended to create operational efficiencies while enabling a 25 percent increase in operational aircraft flights, as compared to legacy carriers. The Navy also expects the new technologies to enable Ford-class carriers to operate with reduced manpower.

Source: U.S. Navy.



Program Essentials

Prime contractor: Huntington Ingalls Industries
Program office: Washington, DC
Funding needed to complete:
R&D: $624.9 million
Procurement: $12,620.7 million
Total funding: $13,275.2 million
Procurement quantity: 1

Program Performance (fiscal year 2017 dollars in millions)

	As of 04/2004	Latest 09/2016	Percent change
Research and development cost	$5,210.1	$5,486.3	5.3%
Procurement cost	$33,377.1	$31,918.1	-4.4%
Total program cost	$38,587.3	$37,539.7	-2.7%
Program unit cost	$12,862.418	$12,513.220	-2.7%
Total quantities	3	3	0.0%
Acquisition cycle time (months)	137	TBD	NA

Total program and unit cost decreases are driven by a decrease in the estimated costs for the third ship (CVN 80), which has not yet been validated by an independent cost estimate.

The Navy reported 9 of the program's 13 critical technologies are mature, though testing continues to reveal issues and delay lead ship (CVN 78) delivery—most recently due to problems with the ship's propulsion plant. CVN 78 construction is nearly complete, but the Navy reported ship delivery was delayed to April 2017. CVN 78 procurement costs remain at the limit of the current legislated cost cap of $12.9 billion, and the Navy has identified $48 million in cost risk from extended testing. The National Defense Authorization Act for Fiscal Year 2016 reduced the cost cap for the first follow-on ship (CVN 79) to $11.4 billion, though we found the funds the Navy has budgeted are likely insufficient to complete ship construction. The Navy adopted a two-phased acquisition approach for CVN 79 and has deferred certain construction activities and costs to after ship delivery.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable		
	FABRICATION START	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

CVN 78 Program

Technology, Design, and Production Maturity

The Navy reported 9 of the program’s 13 critical technologies are mature, though testing continues to reveal issues. CVN 78 began construction with immature technologies and an incomplete design, leading to cost and schedule growth. The Navy completed deadload testing of the electromagnetic aircraft launch system from the ship's deck in 2016. The advanced arresting gear (AAG) began shipboard testing in July 2015, with projected completion in March 2017. The dual band radar (DBR) also began shipboard testing in 2015, despite known problems that could affect air traffic control functionality. Both the AAG and DBR are engaged in concurrent land-based testing. The advanced weapons elevators are also experiencing problems, and, as of January 2017, the Navy projected that only 2 of the 11 elevators would be built and tested by ship delivery. In June 2016, a turbine generator in the ship's propulsion plant experienced a catastrophic failure, likely due to a manufacturing defect. A follow-on review revealed additional problems requiring design modifications to the voltage regulator and protection systems, which has delayed the propulsion plant testing schedule. As a result of key subsystem deficiencies, the Under Secretary of Defense for Acquisition, Technology and Logistics directed an independent review team to identify and mitigate potential technology risks for follow-on ships.

The Navy recently reported additional schedule delays for CVN 78 delivery and major post-delivery test events. Construction continues on CVN 79, which is 23 percent complete. This ship uses the CVN 78 design with some modifications, namely replacing DBR with the Enterprise Air Surveillance Radar suite. The Navy awarded the detail design and construction contract for CVN 79 in June 2015 and the advance procurement contract for CVN 80 in May 2016.

Other Program Issues

In 2007, Congress established a procurement cost cap of $10.5 billion for CVN 78, and lead ship procurement costs have since increased by 23 percent to the current cost cap of $12.9 billion. While CVN 78 construction is nearly complete, the Navy identified $48 million in cost risk and more recent technical issues suggest additional costs, meaning that the current cost cap likely does not represent necessary funding to deliver a complete ship. The National Defense Authorization Act for Fiscal Year 2016 reduced the cap for follow-on ships, including CVN 79’s to $11.4 billion, though costs for this ship may also increase. The Office of the Secretary of Defense projected CVN 79 would exceed the program's cost estimate by about $235 million. We also found that the funds the Navy has budgeted based on CVN 79's cost estimate are likely to be insufficient to complete ship construction. The Navy has expressed confidence that CVN 79 will deliver within its cost cap, which assumes unprecedented efficiency gains in construction—namely that CVN 79 production hours will be significantly lower than CVN 78. The Navy adopted a two-phase acquisition approach for CVN 79 to shift some construction to a post-delivery period. This strategy results in a less capable and complete ship at delivery, and transfers the costs of known capability upgrades to other accounts by deferring work to future maintenance periods—obscuring CVN 79's actual costs.

Program Office Comments

With 93 percent of the CVN 78's test program complete, the Navy has made progress resolving first-of-class issues and has resumed critical-path testing to support delivery in April 2017. The Navy is managing the $48 million cost risk associated with extended shipboard testing and the costs for schedule delay to delivery. The Navy continues to pursue cost mitigation within the program to offset this cost risk to deliver the ship within the cost cap. According to the program, with 26 percent of CVN 79's construction complete, cost performance to-date remains aligned with the contract target to realize an 18 percent reduction in production labor hours from CVN 78. The Navy will deliver a complete and deployable ship at the end of Phase II, with the construction costs from both phases accounted within the cost cap.

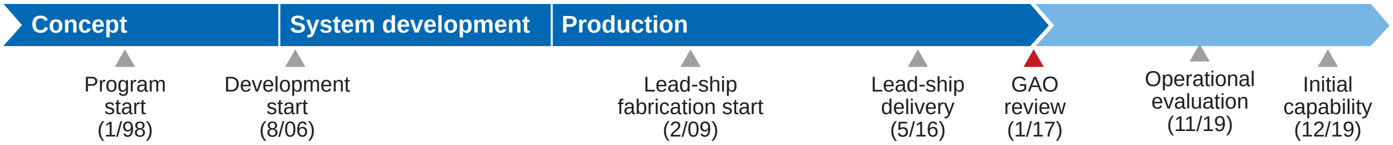
GAO Response

Navy cost mitigation plans will not reduce actual CVN 78 costs; instead, the costs will be shifted to follow-on ships or to other support accounts. CVN 79 cost performance is degrading, and, if trends continue, the ship is at risk of exceeding its cost cap.

DDG 1000 Zumwalt Class Destroyer (DDG 1000)

The DDG 1000 destroyer is a multi-mission surface ship designed to provide advanced capability for littoral operations and land attack to support forces ashore. DDG 1000 class ships feature an integrated power system and a total ship computing environment. The Navy accepted delivery of the lead ship—comprised of the hull, mechanical, and electrical systems—in May 2016. The Navy has scheduled a separate, post-delivery phase to activate and test the lead ships combat systems. The remaining two ships of the class are under construction.

Source: U.S. Navy.



Program Essentials

Prime contractors: BAE Systems, General Dynamics Bath Iron Works, Huntington Ingalls, and Raytheon
Program office: Washington, DC
Funding needed to complete:
R&D: $96.3 million
Procurement: $664.7 million
Total funding: $761.0 million
Procurement quantity: 0

Program Performance (fiscal year 2017 dollars in millions)

	As of 1/1998	Latest 10/2016	Percent change
Research and development cost	$2,471.1	$10,931.2	342.4%
Procurement cost	$35,280.4	$12,714.5	-64.0%
Total program cost	$37,751.5	$23,645.7	-37.4%
Program unit cost	$1,179.734	$7,881.885	568.1%
Total quantities	32	3	-90.6%
Acquisition cycle time (months)	128	264	106.3%

To date, the Navy has fully matured fewer than half of DDG 1000's 11 critical technologies. The program reports that the ship's design is stable, but ongoing development and shipboard testing of technologies pose risk for design changes. The 2016 delivery of the lead ship's hull, mechanical, and electrical systems followed significant technical challenges with the integrated power system, which contributed to an 18-month delay. As the program begins to test the lead ship's combat systems—an effort that relies on stable power from the integrated power system—it faces challenges achieving its cost and schedule baselines. After completing delayed combat system acceptance trials for the lead ship, the Navy will conduct initial operational testing. The program's planned date for initial operating capability has slipped more than 2 years from July 2016 to December 2019.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN START	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

DDG 1000 Program

Technology Maturity

At start of detail design in 2005, the DDG 1000 program had matured 1 of its current 11 critical technologies—an acquisition approach inconsistent with best practices. The DDG 1000 program has since fully matured 5 of 11 critical technologies. The program states that 5 of the remaining 6 will be demonstrated during post-delivery availability and combat systems activation, extending from the second quarter of fiscal year 2017 to the first quarter of fiscal year 2019. The Navy has since delayed the start of this activity to early 2018. Prior to the May 2016 delivery of the lead ship's hull, mechanical, and electrical systems, the program experienced significant technical issues with the integrated power system, a critical technology which supplies power to the ship's propulsion and electronic systems. Challenges were due, in part, to the Navy's decision not to fully test and validate the performance of the system in a representative environment prior to installation on the ship. Program officials noted that combat systems testing and activation relies on stable power, and will introduce new challenges for the power system beyond those encountered to date. After scheduling combat systems acceptance trials for the lead ship in the third quarter of fiscal year 2017, the Navy has delayed this activity to early 2018.

The program reported land-based testing of modifications to the multifunction radar, to include a volume search capability, is complete. In 2017, testing of the modified multifunction radar will move to a Navy test bed for ship self-defense, before initial operational testing aboard the lead ship. The program also reported that the planned date for completion of software development for the class was delayed from January 2016 to December 2017 to prioritize cybersecurity enhancements and software corrections related to integration of the ship's power and engineering control systems. The program did not make a low-rate initial production decision on the long-range land-attack projectile in fiscal year 2016 as planned.

Design and Production Maturity

The DDG 1000 design was not stable at lead ship fabrication start in 2009. Since then, the Navy and its contractors stabilized the design, but ongoing development and shipboard testing of technologies may result in design changes. Delivery of the lead ship's hull, mechanical, and electrical systems was 18 months behind schedule due in part to challenges completing electrical work, with the shipbuilder citing resource shortages and workforce turnover. Program officials noted the lead ship will not complete final contract trials, foregoing an opportunity to identify and mitigate technical and design deficiencies prior to completing construction of the remaining two ships.

As of October 2016, construction of the two remaining ships was 91 and 59 percent complete, respectively. Program officials noted the shipbuilder continues to face challenges in completing electrical work and since March 2016, delivery dates for the remaining two ships have each slipped by about two fiscal quarters. With the Navy as lead integrator, program officials noted that timely delivery of government-furnished equipment to the shipbuilder will be critical to achieving cost and schedule baselines for these ships' hulls, under the terms of their fixed-price construction contracts.

Other Program Issues

During the lead ship's transit between its Maine construction site and California home port, the ship's propulsion system experienced two seawater intrusions which required unscheduled repairs.

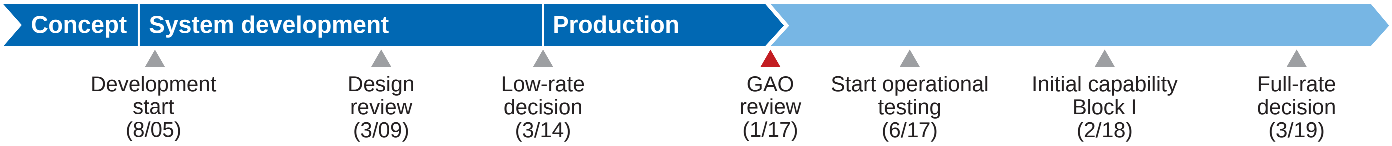
Program Office Comments

In commenting on a draft of this assessment, program officials stated the program reached a significant milestone with delivery of the first-of-class ship in fiscal year 2016. Program officials noted that DDG 1000 underwent an extensive period of testing including three sets of trials prior to delivery and the ship continued test and activation activities during its transit to San Diego. Officials also noted that during transit, seawater contamination occurred in two propulsion motor bearing lubricating oil sumps and it is not uncommon for first-of-class ships to identify deficiencies and undergo repairs during underway periods following construction. According to program officials, the ship’s post-delivery availability will include periods of in-port and at-sea testing and activation of ship systems. Finally the program noted that following combat system activation, the ship will conduct dockside and at-sea trials as well as start operational testing.

Ground/Air Task Oriented Radar (G/ATOR)

The Marine Corps' Ground/Air Task Oriented Radar (G/ATOR) is a three-dimensional, short-to-medium range, multi-role radar designed to detect, identify, and track threats such as incoming cruise missiles, rockets, and artillery. It will replace five legacy radars. G/ATOR is being acquired in blocks, with later blocks focused on software upgrades. We assessed Block 1, which has an air defense and surveillance role, and made observations on Block 2, which will determine enemy firing positions and point of impact for incoming fire.

Source: U.S. Marine Corps.



Program Essentials

Prime contractor: Northrop Grumman
Program office: Quantico, VA
Funding needed to complete:
  R&D: $185.1 million
  Procurement: $1,346.5 million
  Total funding: $1,531.6 million
  Procurement quantity: 36

Program Performance (fiscal year 2017 dollars in millions)

	As of 08/2005	Latest 12/2015	Percent change
Research and development cost	$384.1	$1,061.9	176.5%
Procurement cost	$1,206.0	$1,752.8	45.3%
Total program cost	$1,590.1	$2,818.4	77.3%
Program unit cost	$24.845	$62.632	152.1%
Total quantities	64	45	-27.7%
Acquisition cycle time (months)	66	155	134.8%

The cost data includes G/ATOR Blocks 1 and 2. The acquisition cycle time was calculated for Block 1 only.

The G/ATOR program received approval to enter low-rate initial production (LRIP) in March 2014 with mature technologies, a stable design, and production processes that were demonstrated, but not in control. In early testing, software stability was a major problem that degraded reliability. Since then, software performance and reliability has improved and the program continues to make software updates to address quality and reliability issues. The next opportunity to collect representative data on reliability will be in 2017. Program officials noted G/ATOR transitioned to a new semiconductor technology in 2016, which will be used in initial operational testing and for all future radars produced for the program. A revised test and evaluation master plan (TEMP) capturing the new technology was approved by Director, Operational Test and Evaluation (DOT&E) in March 2016.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▪▪▪▪	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▪▪▪▪	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

G/ATOR Program

Technology and Design Maturity

As of August 2016, the program reported that all six G/ATOR critical technologies are fully mature. Further, the program reported a mature design, with more than 99 percent of design drawings released. Although G/ATOR hardware has proven to be reliable, software maturity and quality problems have affected the reliability of the overall system. After G/ATOR failed to meet its reliability target during developmental testing, a panel of experts convened by the Navy in June 2014 conducted an in-depth analysis of the program and found G/ATOR's reliability requirement was likely unachievable and did not reflect operational needs. In March 2015, the Marine Corps clarified the reliability requirement to ensure it was consistent with G/ATOR's operational mission profile. Since then, software performance and reliability has improved. The program manager noted that the program continues to make software updates to address quality and reliability issues, and that the next opportunity to collect representative reliability data will be 2017 when the first LRIP radar is delivered and tested.

Beginning with radars produced in 2016, the program upgraded the radar's transmit and receive modules by using a newer semiconductor technology. According to program officials, this new gallium nitride (GaN) technology is mature and the new modules will fit inside the system the same as the older gallium arsenide (GaAs) modules, which minimizes design changes. The GaN technology is expected to achieve better performance with higher reliability at a lower cost by reducing the number of modules required.

Production Maturity

The Assistant Secretary of the Navy for Research, Development and Acquisition [ASN(RDA)] approved the program's entry into LRIP in March 2014. At the time of this decision, the G/ATOR program had demonstrated its production processes to the level recommended by DOD, but had not brought them into statistical control, which is inconsistent with best practices. This status is unchanged.

In August 2016, ASN(RDA) approved an increase in LRIP units from 14 to 15 radar systems. According to the program office, the first 6 of the 15 units will use the older GaAs modules and the follow-on 9 will use the newer GaN modules. The program office awarded a contract in August 2016 to Northrop Grumman to procure the 9 GaN radars. According to the program office, the first LRIP deliveries of GaAs radars and GaN radars are expected in early 2017 and 2018, respectively.

Other Program Issues

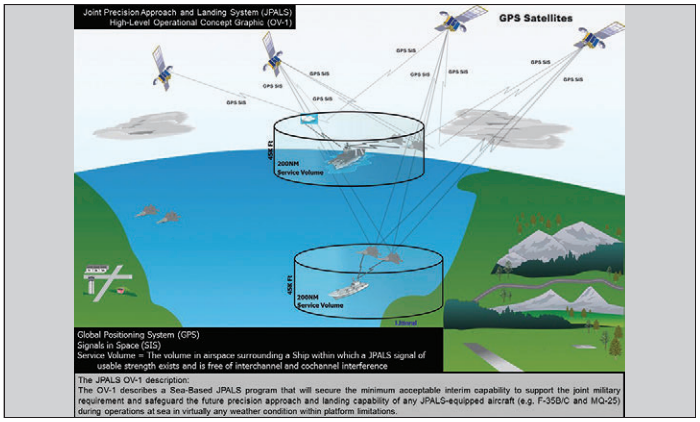
The G/ATOR program revised its test strategy to address reliability concerns raised by the expert panel, to include a test strategy for GaN, and clarify the operational reliability requirements. Originally, the program planned to conduct initial operational testing with the older GaAs configuration, but DOD's DOT&E raised concerns about the production representativeness of this configuration, as a majority of the planned G/ATOR procurements are with the newer GaN modules. Program officials said testing using GaN will occur in 2018. In March 2016, DOT&E approved a revised TEMP capturing the clarified reliability requirements and use of GaN technology.

Program Office Comments

In commenting on a draft of this assessment, the program office provided the following information. G/ATOR has remained on schedule and decreased the estimated total program cost by 10 percent since the program was rebaselined in 2010. The program expects on-time delivery of the first system in February 2017, demonstrating the program remains on schedule and production processes are in control. G/ATOR has successfully demonstrated all Block 1 key performance requirements and the capability to meet all Block 2 performance requirements. There are 15 LRIP systems under contract; 6 systems will be delivered in 2017 to support developmental testing and operational assessments of Blocks 1 and 2, culminating with initial operational capability in 2018. Three systems will be delivered in 2018 to support initial operational test and evaluation and the full rate production decision in 2019. G/ATOR's operational availability has exceeded objective requirements and early software quality challenges are being addressed. Program officials stated they are positioned to deliver the required capabilities to the warfighter per their commitments.

Joint Precision Approach and Landing System (JPALS)

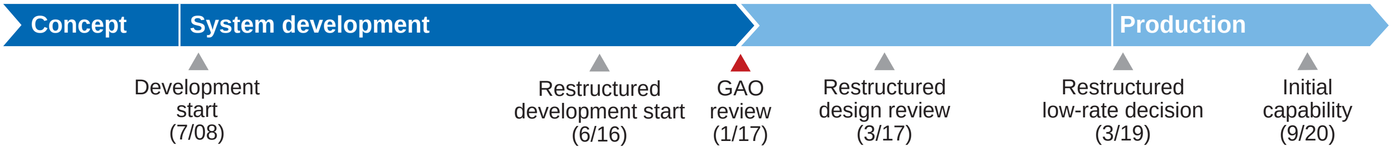
JPALS is a program to develop a GPS-based landing system for aircraft carriers and amphibious assault ships to support operations with the F-35 Lightning II and the MQ-25 Unmanned Aircraft System. The program intends to provide a reliable sea-based precision approach and landing capability in adverse weather conditions. The program has restructured from multiple increments to one, and incorporates capabilities into its base design originally planned for additional increments.



Global Positioning System (GPS)
Signals in Space (SIS)
Service Volume = The volume in airspace surrounding a Ship within which a JPALS signal of usable strength exists and is free of interchannel and cochannel interference

The JPALS OV-1 description:
The OV-1 describes a Sea-Based JPALS program that will secure the minimum acceptable interim capability to support the joint military requirement and safeguard the future precision approach and landing capability of any JPALS-equipped aircraft (e.g. F-35B/C and MQ-25) during operations at sea in virtually any weather condition within platform limitations.

Source: U. S. Navy.



Program Essentials

Prime contractor: Raytheon
Program office: Lexington Park, MD
Funding needed to complete:
R&D: $437.4 million
Procurement: $402.9 million
Total funding: $840.2 million
Procurement quantity: 23

Program Performance (fiscal year 2017 dollars in millions)

	As of 07/2008	Latest 10/2016	Percent change
Research and development cost	$859.2	$1,449.8	68.7%
Procurement cost	$231.3	$402.9	74.2%
Total program cost	$1,098.0	$1,860.2	69.4%
Program unit cost	$29.677	$56.370	89.9%
Total quantities	37	33	-10.8%
Acquisition cycle time (months)	75	194	158.7%

JPALS originally began development in July 2008, but the Navy restructured the program in 2014 due to affordability concerns, as well as other military services and civilian plans to continue using their current landing systems. The Navy assessed the restructured program through a new system-level preliminary design review in March 2016 and approved a development restart in June 2016. The program previously accepted delivery of eight prototypes, and plans to procure two additional ones. These prototypes are expected to support JPALS developmental testing and F-35 Lightning II initial capability. Program officials reported conducting shipboard developmental testing in 2016, and the program plans to hold a critical design review in March 2017. The JPALS program has also contracted for a trade study to assess options for integrating future capability updates.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

JPALS Program

Technology, Design, and Production Maturity

JPALS entered system development in July 2008 with technologies that were nearing maturity. The program also held a critical design review in December 2010, which evaluated a design that later proved unstable. In June 2014, the Navy restructured the JPALS program due to funding concerns and to accelerate the development of aircraft auto-land capabilities. The Navy also attributed the restructuring to a review it conducted of its precision approach and landing capabilities, as well as the other military services and civilian plans to continue use of their current landing systems rather than investing in the new JPALS capability.

Following the program restructuring, the Navy began reassessing JPALS's technology maturity and design stability to account for the changes. The program reported conducting a system requirements review in March 2015 and a system-level preliminary design review (PDR) in March 2016. Subsequently, the Under Secretary of Defense for Acquisition, Technology and Logistics delegated milestone decision authority to the Navy. In June 2016, the Navy approved the start of engineering and manufacturing development for the restructured JPALS program. At that time, the Navy also approved the program's new procurement cost and quantity estimates. Because JPALS functionality is primarily software-based, the restructured program will require new software development. The PDR set a new technology baseline for software development and did not identify any critical manufacturing processes. The program's next technical review will be the critical design review planned for March 2017. At that review, the program will update the total number of expected design drawings, as well as reevaluate the need for any critical manufacturing processes. Program officials reported completing shipboard developmental testing aboard a Nimitz-class aircraft carrier in August 2016 and beginning testing aboard an America-class amphibious assault ship in October 2016.

Prior to the restructuring, the program had accepted delivery of eight prototypes—also referred to as engineering development models. The program awarded a contract in September 2016 to upgrade these prototypes, as well as to procure two additional prototypes for developmental testing. These prototypes will be production-representative, and the JPALS program plans to use them to provide early operational capability in support of F-35 Lightning II initial capability in fiscal year 2018.

Other Program Issues

Because JPALS is GPS-based, it will need to be compliant with any updates to DOD's GPS systems. The JPALS program contracted for a trade study to determine future GPS integration and implementation options, as well as potential costs and schedule issues. The program estimates the trade study will be completed no later than fiscal year 2019.

Program Office Comments

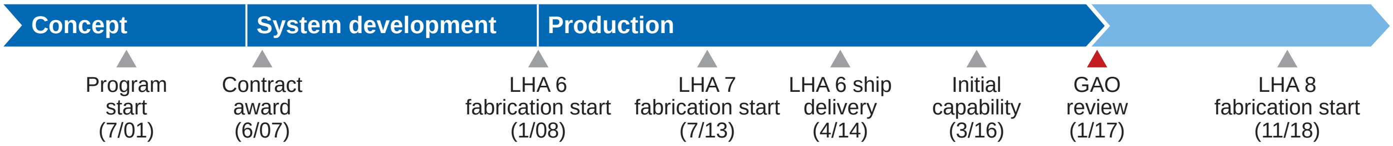
In commenting on a draft of this assessment, the program office noted "fact-of-life" changes in 2013 demanded the Navy's Precision Approach and Landing Capabilities Roadmap be revisited. By June 2013, the Navy validated the need for only the ship-based JPALS requirements. The associated reduction of JPALS quantities precipitated unit cost growth in excess of statutory critical thresholds. The Navy subsequently accelerated future JPALS capabilities into a single program to meet the sea-based requirement. The program reported completing PDR and development restart in March and June 2016, respectively.

Military GPS user equipment purchased after fiscal year 2017 is required to be M Code capable—a new military GPS signal designed to further improve anti-jamming and secure access to GPS signals for military users. JPALS has contracted for a trade study to identify alternatives for the incorporation of M Code into the JPALS ship systems. The results will be presented no later than fiscal year 2019. The program office also provided technical comments, which we incorporated where appropriate.

LHA 6 America Class Amphibious Assault Ship (LHA 6)

The Navy's LHA 6 class will replace the LHA 1 Tarawa-class amphibious assault ships. The LHA 6 class design is based on the fielded LHD 8 and consists of three ships. The ships feature enhanced aviation capabilities and are designed to support Marine Corps assets in an expeditionary strike group. LHA 6 construction began in December 2008 with delivery in April 2014. LHA 7 construction began in July 2013 with delivery expected in December 2018. The Navy plans to exercise an option for detail design and construction of LHA 8 in summer 2017.

Source: Huntington Ingalls Industries



Program Essentials

Prime contractor: Huntington Ingalls Incorporated
Program office: Washington, DC
Funding needed to complete:
R&D: $38.6 million
Procurement: $2,755.1 million
Total funding: $2,794.9 million
Procurement quantity: 1

Program Performance (fiscal year 2017 dollars in millions)

	As of 01/2006	Latest 09/2016	Percent change
Research and development cost	$239.6	$454.2	89.5%
Procurement cost	$3,209.7	$9,532.5	197.0%
Total program cost	$3,449.3	$9,989.3	189.6%
Program unit cost	$3,449.293	$3,329.777	-3.5%
Total quantities	1	3	200.0%
Acquisition cycle time (months)	146	176	20.5%

LHA 6 lead ship construction began in December 2008 with mature technologies but an incomplete design. The Navy accepted delivery of the ship in April 2014 after a 20-month delay, and the ship has begun post-delivery activities. In March 2016, the program completed post shakedown availability and achieved initial operating capability—7 months ahead of schedule. LHA 7, which largely shares the LHA 6 design, began construction in July 2013 and is expected to deliver in December 2018. Design changes to LHA 8 are more significant and include the addition of a well deck. The program awarded an advanced engineering and procurement of long lead time material contract for LHA 8 in June 2016. This contract includes an option for LHA 8 detail design and construction, which the program intends to exercise in summer 2017.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	●	●
Product design is stable		
	FABRICATION START	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

LHA 6 Program

Technology, Design, and Production Maturity

The program awarded a construction contract for the lead ship, LHA 6, in June 2007 after determining the ship relied on six non-critical subsystems, but no critical technologies, to achieve capabilities. The Navy later restructured the acquisition program for one of these subsystems, the Joint Precision Approach and Landing System, to focus it on aircraft auto-land capabilities. Full integration of this subsystem is not expected until 2020. In the interim, the LHA 6 program will use backup aviation control systems to meet requirements.

LHA 6 is a modification of the LHD 8. When LHA 6 construction began in December 2008, the ship's design was only 77 percent complete. The Navy accepted delivery of LHA 6 in April 2014, 20 months late and more than $500 million over cost. The program declared initial capability in March 2016. Officials expect operational testing of LHA 6 to conclude in June 2017. Following delivery, the program had to execute design changes to accommodate the F-35 at a cost of nearly $60 million. According to officials, testing of these modifications to accommodate the F-35 will complete in fiscal year 2019. LHA 6 is scheduled to conduct its first deployment in mid-2017.

Construction of the first follow-on ship, LHA 7, began in July 2013. The LHA 7 design incorporates modifications to the LHA 6 design, and, as of September 2016, approximately 58 percent of the ship was built. The program plans to launch, or transfer to water, LHA 7 in mid-2017. The program anticipates a delay in the ship's delivery of approximately 6 months to December 2018 in order to execute design changes required for operations with the F-35. Program officials said the shipbuilder improved its performance on LHA 7 by implementing lessons learned and re-hiring staff from the lead ship construction. In addition, the Navy provided new incentives to the shipbuilder to promote a higher quality of work, and program officials noted improvements since these were implemented. However, the shipbuilder is not currently performing efficiently enough to construct the ship within planned costs.

The Navy held a limited competition between two shipbuilders and, in June 2016, awarded a contract to the current builder, Huntington Ingalls, to begin planning LHA 8 detail design and construction. Design changes on LHA 8 will be more significant than those on LHA 7, as the Navy is incorporating a well deck to accommodate two landing craft. To integrate a well deck, program officials estimate approximately 35 percent of LHA 8’s design will change. Program officials told us they expect detail design plans to include three-dimensional models, unlike the two-dimensional drawings used for the detail design of LHA 6 and LHA 7.

Other Program Issues

In January 2015, DOD's Director, Operational Testing and Evaluation (DOT&E) expressed concern that LHA 6's self-defense system is incapable of defending against certain anti-ship cruise missile threats. In January 2016, DOT&E acknowledged actions taken by the program office to improve performance, but stated the LHA's 6’s self-defense system is unlikely to meet all requirements. DOT&E also expressed concerns regarding the performance of LHA 6's missile launch system. In response, the Navy is investigating options to modify or replace the system, but in the interim has modified launch procedures and increased the supply of replacement parts.

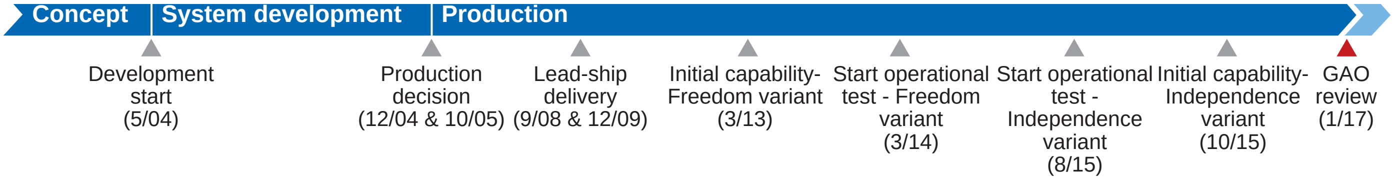
Program Office Comments

In commenting on a draft of this assessment, the Navy reported LHA 6 completed its post shakedown availability in March 2016. LHA 6's initial capability was declared less than one week later. Program officials reported the ship is currently conducting fleet exercises and other required certifications, and they expect to complete LHA 6 Initial Operational Test and Evaluation in summer 2017, prior to initial deployment. Program officials reported LHA 7 construction is not experiencing labor resource issues as seen in the past and continues to address labor efficiency concerns to control cost. Program officials reported LHA 7 is on schedule to meet its contract delivery date of December 4, 2018. LHA 8’s planning, advanced engineering, and procurement of long lead time material began in June 2016 with contract award to Huntington Ingalls. Program officials expect to exercise the LHA 8 detail design and construction contract option in summer 2017.

Littoral Combat Ship (LCS)

The Navy's Littoral Combat Ship (LCS) is designed to perform mine countermeasures, antisubmarine warfare, and surface warfare missions. It consists of the ship itself, or seaframe, and the mission package it deploys. The Navy is buying two designs—the Freedom variant, a steel monohull (LCS 1 and odd numbered ships built by Lockheed Martin), and the Independence variant, an aluminum trimaran (LCS 2 and even numbered ships built by Austal)—and has awarded contracts for 26 seaframes with plans for 2 more in fiscal year 2017. We assessed both designs.

Sources: Lockheed Martin (left); General Dynamics (right).



Program Essentials

Prime contractors: Austal USA, Lockheed Martin

Program office: Washington Navy Yard, DC

Funding needed to complete:

- R&D: $678.9 million
- Procurement: $10,291.8 million
- Total funding: $11,082.1 million
- Procurement quantity: 14

Program Performance (fiscal year 2017 dollars in millions)

	As of 05/2004	Latest 10/2016	Percent change
Research and development cost	$962.0	$3,971.6	312.8%
Procurement cost	$511.6	$22,429.2	4,284.5%
Total program cost	$1,473.7	$26,650.5	1,078.4%
Program unit cost	$368.423	$666.262	80.8%
Total quantities	4	40	900%
Acquisition cycle time (months)	41	119	190.2%

Cost data are for the seaframe program only, which includes the cost of 29 LCS and 11 modified LCS/frigates in the current program baseline. Research and development funding includes detail design and construction of two ships.

The LCS seaframe program, now more than 12 years into production, has yet to demonstrate the maturity of two critical technologies—the aluminum hull structure and launch, handling, and recovery system of the Independence variant. The Navy undertook shock trials on both variants as well as a survivability trial on LCS 4. Both sets of tests revealed design deficiencies. Since December 2015, five LCS seaframes experienced engineering casualties that limited their availability. The Navy announced significant changes to LCS crewing and support concepts in response. Both shipbuilders continue to deliver LCS seaframes significantly behind schedule and in excess of cost targets.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable		
	FABRICATION START	
• Complete basic and functional design to include 100 percent of 3D product modeling	○	●

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained ▨ Not applicable

LCS Program

Technology Maturity

Sixteen of the 18 critical technologies—the total number of technologies for both designs—are mature. However, efforts continue to further mature two Independence variant technologies—the aluminum hull structure and the launch, handling, and recovery system. The Navy reported that it expects the results of now completed survivability testing of the aluminum structure by early 2017. Regarding the launch, handling, and recovery system, the program demonstrated unmanned operations during LCS 8's acceptance trial, but has yet to receive Navy certification to conduct manned operations as intended.

Design and Production Maturity

The LCS 4 survivability trial in January 2016 revealed weaknesses in the Independence variant design, according to the Director, Operational Test and Evaluation (DOT&E). In July 2016, LCS 6 completed shock trials in accordance with the DOT&E approved plan. This trial was conducted at a reduced severity due to serious concerns about the potential for damage to the ship. LCS 5 did not complete the entire shock trial because the Navy stopped testing in September 2016 due to concerns with the shock environment, personnel, and equipment. The Navy and DOT&E disagree on the need to complete this trial. The program now expects results of rough water trials—testing that occurred and resulted in damage on both designs several years ago—by June 2017.

Since December 2015, five of the eight delivered LCS—ships of both variants—have suffered engineering casualties, which the Navy attributes to shortfalls in crew training, seaframe design, and construction quality. According to the Navy, these failures have resulted in substantial downtime and costs for repairs or replacements. We have found the Navy is responsible for paying for the vast majority of these types of damage, deficiencies, and defects on ships already delivered. While addressing deficiencies in the designs of each variant to increase the operational availability of the ships in-service, the Navy is also working to incorporate changes on follow-on ships. The Navy plans to make improvements to LCS either during construction or sometime after delivery, if funding is available.

To date, nine LCS have been delivered and 13 are in various phases of construction. In 2015, the Navy provided the LCS shipbuilders schedule relief; however, even with modified ship delivery dates, both shipbuilders continue to deliver LCS seaframes significantly behind the adjusted schedule. Program officials recently reported the shipyards would not deliver four LCS in fiscal year 2016 as planned. In addition to lagging schedule performance, the shipyards continue to deliver seaframes in excess of cost targets.

Other Program Issues

Following a pattern of LCS engineering casualties, in February 2016, the Navy initiated a program review to assess, among other things, LCS crewing, training, and maintenance. Recommended actions included, returning to a "Blue/Gold" crew rotation model; merging the seaframe and mission package crew into a single, approximately 70-person crew focused on a single mission area; and designating LCS 1-4 as test ships to support testing between fiscal years 2017 and 2022. In merging the seaframe and mission package crew, the Navy acknowledged that switching the LCS mission package—once a key building block of the LCS concept—will occur less often than originally conceived.

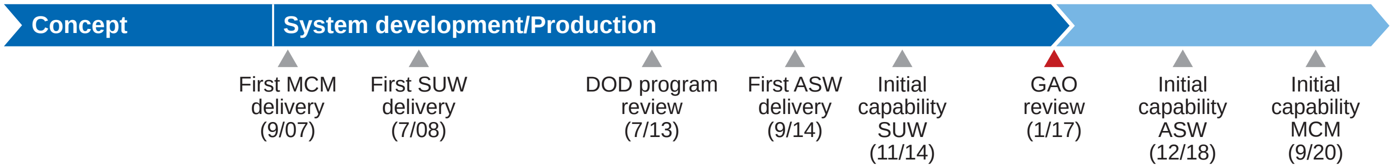
Program Office Comments

In addition to providing technical comments, the program office noted as of January 2017, there are nine LCS in the Fleet, with another 17 on contract. By 2018, LCS will be the second largest surface ship class in the Navy. Program officials reported the LCS design is stable, meets all validated and approved requirements, and is in full serial production at both shipyards. Program officials also reported the LCS program is on budget and below the congressional cost cap and hull over hull performance continues to improve, stabilizing the production cycle. Program officials stated LCS 5 and 6 successfully met all test objectives of the approved shock trial test plan, demonstrating the ability of both variants to survive the effects of underwater shock associated with the close-proximity detonation of a 10,000 pound charge. The program office stated they have completed required testing and are incorporating lessons learned into future LCS and frigates.

Littoral Combat Ship-Mission Modules (LCS Packages)

The Littoral Combat Ship (LCS) will provide mine countermeasures (MCM), surface warfare (SUW), and antisubmarine warfare (ASW) capability using mission packages. Packages include weapons and sensors launched and recovered from LCS seaframes. The Navy plans to deliver these capabilities incrementally and has set interim requirements that are below the baseline requirements for some increments. We assessed mission packages' progress against the threshold requirements that define the baseline capabilities currently expected for each package.

Source: U. S. Navy.



Program Essentials

Prime contractor: Northrop Grumman Systems

Program office: Washington Navy Yard, DC

Funding needed to complete:

- R&D: $518.3 million
- Procurement: $3,657.4 million
- Total funding: $4,192.9 million
- Procurement quantity: 43

Program Performance (fiscal year 2017 dollars in millions)

	As of 08/2007	Latest 09/2016	Percent change
Research and development cost	NA	$2,611.6	NA
Procurement cost	$3,535.4	$4,456.3	26.0%
Total program cost	NA	$7,100.7	NA
Program unit cost	NA	$110.949	NA
Total quantities	64	64	0.0%
Acquisition cycle time (months)	NA	NA	NA

The current estimate does not include $3.6 billion of procurement funding for life cycle replacement and modernization of mission systems.

The Navy has accepted delivery of 15 mission packages without demonstrating whether any meet full threshold capability requirements for seaframes. These deliveries followed Navy decisions to design and produce mission package systems prior to maturing critical technologies. The Navy has recently revised its approach to develop the MCM package following the discovery of significant reliability issues during a series of development tests in fall 2015. The Navy intends to test the revised MCM package against threshold requirements by late fiscal year 2020. A portion of the SUW package has met its interim requirements on one of the seaframe variants. To meet threshold requirements, the Navy is currently modifying an Army missile it plans to test in fiscal 2018. ASW package initial capability has been delayed due to weight and contracting issues and is now scheduled for fiscal year 2019.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▪▪▪▪	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained ▪▪▪▪ Information not available

○ Knowledge not attained ▨ Not applicable

LCS Packages Program

Mine Countermeasures (MCM)

The Navy designed and produced MCM mission package systems prior to maturing critical technologies. The Navy accepted seven MCM packages without demonstrating they meet threshold performance requirements and, is now replacing a key system—the remote multi-mission vehicle (RMMV). There are six MCM systems (Near Surface Detection, Airborne Mine Neutralization, Remote Minehunting, Coastal Mine Reconnaissance, Buried Minehunting, and Unmanned Mine Sweeping) the Navy plans to assemble and fully test in fiscal year 2020. After the Navy suspended developmental testing in October 2015 following the discovery of significant reliability issues, it studied the package and revised its approach. The Navy is now replacing the RMMV, which towed the AQS-20A sonar, with an unmanned boat. The new boat rides on the surface of the water as opposed to the semi-submersible RMMV. Program officials state the boat will be easier to launch and recover but could be susceptible to wave-movement, which may make it more difficult to find mines. The Near Surface Detection Module and Airborne Mine Neutralization Modules achieved initial capability in 2016. The remaining systems are still in development and are planned to be tested over the next several years.

Surface Warfare (SUW)

The Navy designed and produced SUW mission package systems prior to demonstrating the maturity of key systems leading to changes and delays to the SUW package. The Navy has accepted eight SUW packages with no deliveries planned for fiscal year 2017. One package currently consists of two 30 millimeter guns, an armed helicopter, and two rigid hull inflatable boats. In August 2014, the Navy found that the current package met interim performance requirements on the Freedom variant and, in 2015, the Navy tested this part of the package on the Independence variant. To meet threshold requirements a surface-to-surface missile is required. According to program officials, initial missile demonstrations were successful, but operational testing was delayed by about a year to fiscal year 2018 due to ship integration issues.

Antisubmarine Warfare (ASW)

The Navy reconfigured the ASW package after determining planned systems would not provide adequate capability. According to the Navy, the ASW systems are mature as they have been fielded by U.S. Navy and foreign navies. Navy program officials stated that the package’s weight issues have been resolved, and the Navy has purchased an initial ASW package to be used for testing. The Navy is now planning to meet the threshold requirement for ASW in fiscal year 2019, a 2-year delay from last year's estimate.

Other Program Issues

The Navy will not achieve the capability to meet threshold requirements for all three of the mission packages until late fiscal year 2020, by which time it plans to have taken delivery of 24 ships. Starting in 2018, the Navy plans to modify LCS as a frigate and permanently install most of the ASW and SUW mission packages. These changes have, to date, not deterred the Navy from its plans to purchase 64 mission packages.

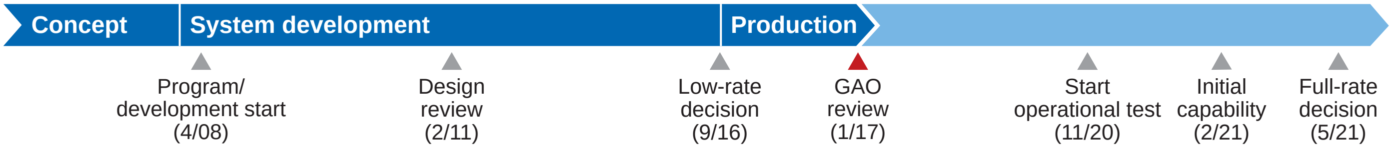
Program Office Comments

In commenting on a draft of this assessment, the Navy reported it is delivering operationally effective mission package capability to the fleet as it mature increments. The Navy stated it is purchasing the quantity of mission systems and packages needed for system integration, crew training, developmental and operational testing, and LCS deployments. The Navy reports it is purchasing the systems in accordance with relevant laws and DOD regulations. The SUW package achieved initial capability in fiscal 2015 and will meet requirements with the surface to surface missile module in fiscal 2018. ASW capability is planned to have an initial capability and meet requirements in fiscal 2019. The MCM package is delivering systems as they mature. Due to reliability of the RMMV, the Navy reports it is restructuring the MCM package to perform the minehunting mission with a different vehicle. The MCM package is planned to achieve an initial capability in fiscal year 2020. The Navy reported it intends to adjust the program's package quantities in 2017 to support changes to the LCS and frigate programs.

MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)

The Navy's MQ-4C Triton is intended to provide persistent maritime intelligence, surveillance, and reconnaissance (ISR) data collection and dissemination capability. Triton is planned to be an unmanned aircraft system operated from five land-based sites worldwide as part of a family of maritime patrol and reconnaissance systems. Based on the Air Force's RQ-4B Global Hawk air vehicle, Triton is part of the Navy's plan to recapitalize its airborne ISR assets by the end of the decade.

Source: Northrop Grumman.



Program Essentials

Prime contractor: Northrop Grumman Systems Corporation
Program office: Patuxent River, MD
Funding needed to complete:
R&D: $120.3 million
Procurement: $7,951.8 million
Total funding: $8,165.8 million
Procurement quantity: 63

Program Performance (fiscal year 2017 dollars in millions)

	As of 02/2009	Latest 09/2016	Percent change
Research and development cost	$3,407.8	$4,084.4	19.9%
Procurement cost	$10,113.1	$8,733.4	-13.6%
Total program cost	$13,935.8	$13,123.1	-5.8%
Program unit cost	$199.083	$187.473	-5.8%
Total quantities	70	70	0.0%
Acquisition cycle time (months)	92	154	67.4%

R&D costs of $681.2 million and procurement costs of $674 million associated with phased modifications to update sensor and system performance are not included in the cost data.

The MQ-4C Triton program entered low-rate production in September 2016 with a mature critical technology and a stable design, but prior to demonstrating full control of critical manufacturing processes. Developmental challenges caused the Navy to delay production start by over 3 years, and full-rate production has been delayed from September 2018 to May 2021. The program is developing new capabilities for Triton, including enhanced intelligence sensors and an aircraft avoidance capability. The program plans to integrate these into production aircraft beginning in fiscal years 2020 and 2024, respectively. Testing delays contributed to program decisions to concurrently develop software packages needed for Triton's baseline configuration and future upgrades. The baseline and enhanced intelligence capabilities are now scheduled to be demonstrated prior to full-rate production.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	○	○

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

MQ-4C Triton Program

Technology, Design, and Production Maturity

The Triton program entered low-rate production in September 2016. At production start, the program's only critical technology for its baseline configuration—the hydrocarbon sensor—was mature, and the Triton system design was stable. According to best practices criteria, technology maturity and design stability should occur prior to development start and critical design review, respectively, neither of which the Triton program achieved.

Further, Triton production began before the contractor brought its manufacturing processes for wing production under control, which was inconsistent with best practices. The Defense Contract Management Agency previously identified quality issues with the wing supplier and defects such as improperly drilled holes and gaps in the adhesive that bonds the wing skin to the wing frame. Triton wing quality problems continue to delay wing delivery for some test aircraft being built and further delays could impact testing schedules. According to the program, the subcontractor increased its work force and replaced leadership to expedite wing delivery and improve its manufacturing processes.

Triton developmental challenges caused the Navy to delay production start by over 3 years. In order to accommodate cost and schedule growth, the Navy delayed the start of full-rate production—from September 2018 to May 2021. As part of the new schedule, the program plans to increase the quantity of aircraft acquired during low-rate production from 10 to 15, increasing the risk that more vehicles may require design changes prior to demonstrating Triton capabilities.

The program is also developing new Triton capabilities it will implement in two future upgrade packages. The first upgrade will include enhanced intelligence capabilities, which the program plans to integrate into production in 2020, including retrofits to the first six production aircraft. The second upgrade will include electronic defense upgrades and an aircraft avoidance radar system. This upgrade package is scheduled to be integrated into the production line for the 19th production aircraft scheduled to be delivered in fiscal year 2024. The Navy originally planned to include the aircraft avoidance radar in the baseline configuration, but deferred this due to technical challenges.

The Triton program previously planned to complete the software to support the baseline configuration before initiating software development for the planned upgrades. However, under the new schedule the program will begin the enhanced intelligence software upgrade before completing the baseline software, thus increasing concurrency risk. The program now intends to demonstrate the software for the baseline configuration, along with the enhanced intelligence capabilities, by the May 2021 full-rate production date.

Other Program Issues

The Navy plans to deploy aircraft in 2018 that provides intelligence surveillance and reconnaissance capability, but some capabilities such as high resolution radar and fire detection have been deferred to future software builds to address cost and schedule growth. The Navy will field them as an early operational capability and plans to support the deployment with operational testing beginning in 2017.

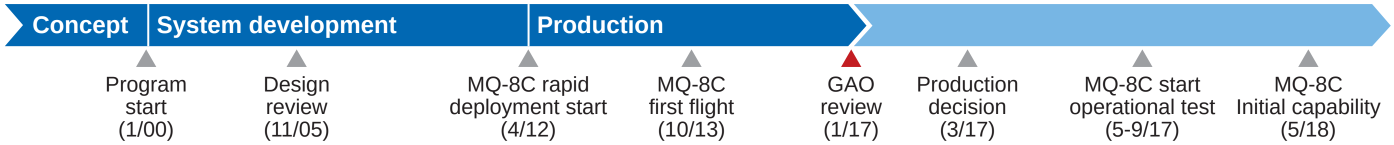
Program Office Comments

According to program officials, the MQ-4C Triton unmanned aircraft system program continues to demonstrate success during development and early operational flight and ground test. Officials noted modifications to install the baseline early operational capability software build into all test assets are ongoing in support of flight testing to commence in the second quarter of fiscal year 2017. Officials further noted MQ-4C Triton low-rate initial production has commenced and the program is planning to receive two additional test aircraft in the fourth quarter of fiscal year 2017 to subsequently support an operational test period.

MQ-8 Fire Scout

The Navy's MQ-8 unmanned aerial vehicle is intended to provide real-time imagery and data in support of intelligence, surveillance, and reconnaissance missions. The MQ-8 system is comprised of one or more air vehicles with sensors, a control station, and ship equipment to aid in vertical launch and recovery. The air vehicle operates from ships and the ground. The MQ-8 is intended for use in various operations, including surface, anti-submarine, and mine warfare, and it includes B and C variants. We assessed the latest variant, the MQ-8C.

Source: Northrop Grumman Systems Corporation.



Program Essentials

Prime contractor: Northrop Grumman
Program office: Patuxent River, MD
Funding needed to complete:
  R&D: $77.4 million
  Procurement: $562.0 million
  Total funding: $639.4 million
  Procurement quantity: 11

Program Performance (fiscal year 2017 dollars in millions)

	As of 12/2006	**Latest 09/2016**	**Percent change**
Research and development cost	$648.6	$1,246.3	92.1%
Procurement cost	$1,825.0	$1,689.0	-7.4%
Total program cost	$2,836.8	$2,935.4	3.5%
Program unit cost	$16.027	$41.934	161.6%
Total quantities	177	70	-60.5%
Acquisition cycle time (months)	104	170	63.5%

The MQ-8C program has mature technologies and a stable design. The MQ-8C is a larger airframe but shares technology previously developed for the MQ-8B. The MQ-8C bypassed many standard acquisition practices, accepting risk for a quicker cycle time, because it was procured under the rapid deployment capability process. According to program officials, the program plans to start operational testing in spring and summer 2017 and demonstrate initial capability for the MQ-8C in May 2018. We could not assess production process maturity because the program does not collect statistical process control data or manufacturing readiness levels. The Navy restructured the program in 2015 after reporting to Congress the program had incurred unit cost growth in excess of statutory critical thresholds.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▪▪▪▪	▪▪▪▪
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▪▪▪▪	▪▪▪▪
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▪▪▪▪	▪▪▪▪
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained ▪▪▪▪ Information not available
○ Knowledge not attained ▨ Not applicable

MQ-8 Fire Scout Program

Technology and Design Maturity

The MQ-8C relies on mature technologies common to the MQ-8B and has a stable design. According to the program office, the MQ-8C has 90 percent commonality with the previously developed MQ-8B. The primary differences between the two are structural modifications to accommodate the MQ-8C's larger airframe and fuel system. The MQ-8C was initiated under the Navy's rapid deployment capability acquisition process, which program officials stated enabled the program to bypass many standard acquisition practices designed to reduce risk in favor of a speedier acquisition cycle time. The Navy completed its first MQ-8C flight in October 2013. The program will continue with developmental testing and transition to operational testing in the spring and summer 2017. Despite being a separate increment of capability, the MQ-8C did not have a separate development start decision review which, according to program officials, was not required.

Production Maturity

The program awarded a contract for development and production of the MQ-8C in April 2012 after production of the MQ-8B variant stopped following delivery of 30 aircraft. As of September 2016, the program has taken delivery of 19 MQ-8C aircraft, which program officials consider low-rate initial production units. An additional 11 MQ-8C aircraft are under contract, including one fiscal year 2017 aircraft. According to program officials, the program plans to make a full-rate production decision, previously scheduled for May 2016, in the second quarter of fiscal year 2017. In addition, the program reports it plans to start operational testing in September 2017 and demonstrate initial operational capability in May 2018.

We could not assess whether critical manufacturing processes were in control as the program does not collect data on statistical manufacturing process controls or assess process capabilities using manufacturing readiness levels. Rather, the program office collects metrics on the status of production from the prime contractor, such as discovery of manufacturing defects. Program officials noted the MQ-8C has a commercial airframe procured by the government and provided directly to the prime contractor as government-furnished equipment for conversion to an MQ-8C. The prime contractor is responsible for integration of the avionics and working with the aircraft manufacturer to modify the commercial airframe with increased capacity fuel tanks.

Other Program Issues

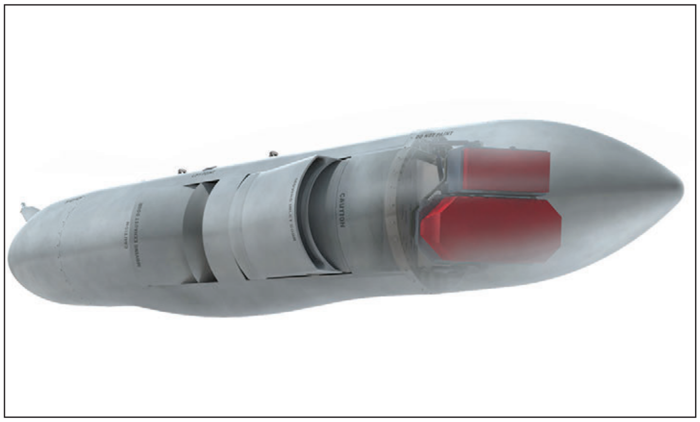
In June 2014, the program was certified as essential to national security and allowed to progress after reporting to Congress it had incurred unit cost growth in excess of statutory critical thresholds. Program officials told us the Navy restructured the program in 2014, with revised quantities of both variants, because the MQ-8C had more endurance than the MQ-8B, which reduced the total quantity of MQ-8 units required to support the Littoral Combat Ship. Following this determination, program officials said they stopped production of the MQ-8B and moved forward with only producing the MQ-C.

Program Office Comments

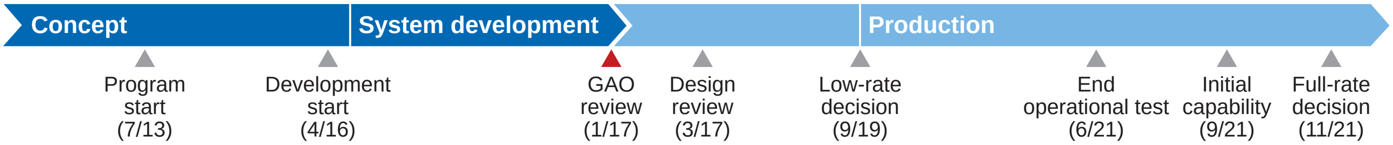
In commenting on a draft of this assessment, the program office noted the MQ-8C program is executing with no significant issues. The program further noted it awaits availability of the Littoral Combat Ship to complete MQ-8C testing, including planned start of operational testing in spring and summer 2017. The program office stated the MQ-8B continues deployments aboard the Littoral Combat Ship, including the first deployment with an upgraded radar. In addition, the program office provided technical comments, which were incorporated where deemed appropriate.

Next Generation Jammer Increment 1

The Navy's Next Generation Jammer (NGJ) is being developed as an external jamming pod system fitted on EA-18G Growler aircraft. It is expected to replace the ALQ-99 tactical jamming system and provide enhanced airborne electronic attack capabilities to disrupt adversaries' use of the electromagnetic spectrum. The Navy plans to field capabilities in three increments for different radio frequency ranges, beginning with Increment 1 (mid-band) in 2021, with Increments 2 and 3 (low- and high-band) to follow. We assessed Increments 1 and 2.



Source: Raytheon Corp.



Program Essentials

Prime contractor: Raytheon
Program office: Patuxent River, MD
Funding needed to complete:
  R&D: $2,207.2 million
  Procurement: $4,074.7 million
  Total funding: $6,289.0 million
  Procurement quantity: 131

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 09/2016	Percent change
Research and development cost	NA	$3,516.3	NA
Procurement cost	NA	$4,074.7	NA
Total program cost	NA	$7,598.2	NA
Program unit cost	NA	$56.283	NA
Total quantities	NA	135	NA
Acquisition cycle time (months)	NA	98	NA

NGJ Increment 1 entered development in April 2016 with its critical technologies nearing maturity. Consistent with best practices and statutory requirements, the program completed a preliminary design review prior to starting development. Program officials state NGJ is on track to hold its critical design review (CDR) in early 2017. As of November 2016, the contractor had released almost 76 percent of its design drawings. The Naval Air Systems Command benchmark for released drawings at critical design review is 80 percent, which is short of the 90 percent threshold under GAO identified best practices. The program's main risks include meeting weight and power requirements and integrating the jamming pods with the aircraft. NGJ is participating in a pilot program that allows it to streamline and tailor some acquisition processes.

Attainment of Product Knowledge

As of January 2017

	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

NGJ Increment 1 Program

Technology Maturity

The NGJ program entered system development in April 2016, with its seven critical technologies approaching maturity. In November 2015, the program conducted an assessment of these technologies, which includes two separate arrays—each with different transmit/receive modules, circulators, and apertures—as well as a power generation system. All technologies were assessed as nearing maturity based on subsystem prototype testing conducted prior to starting development.

Design and Production Maturity

Program officials stated NGJ is on track to hold its CDR in March 2017, but the program is not following GAO identified best practices for this milestone. As of November 2016, the contractor had released about 76 percent of design drawings. This positions the program to meet the Naval Air Systems Command benchmark of releasing 80 percent of its design drawings by CDR. However, GAO identified best practices call for releasing 90 percent of drawings by CDR. The program also does not plan to test an early system prototype of the jamming pod before its CDR. GAO identified best practices recommend such testing prior to this key review to help determine whether the design will work as intended. The first test of a fully functional jamming pod is planned for May 2019, 4 months before the program's planned start of production.

However, program officials stated that the significant prototyping and associated testing conducted to date address NGJ's principal risks, which include weight, integration complexity, and transmit power. The program recently addressed the severity of its power risk by taking several mitigation actions. In addition, the program is managing software risk through modeling and simulation. The program is consulting with systems engineering experts from the Office of the Secretary of Defense for input regarding NGJ software metrics.

Regarding production maturity, NGJ officials stated they plan to identify critical manufacturing processes and key product characteristics at CDR. NGJ officials also stated they have begun assessing manufacturing readiness levels.

Other Program Issues

In September 2015, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) approved NGJ as the first program in the Skunk Works pilot, which aims to eliminate non-value added processes in order to deliver capabilities on time and within budget. NGJ officials stated they had direct access to the USD AT&L and other senior acquisition officials, and some approval authorities were delegated to lower levels. For example, the contract award authority was delegated down to Naval Air Systems Command, which officials said saved 2 to 3 months of time in the contract negotiation process. NGJ officials said the Skunk Works designation was beneficial to the program.

Studies for NGJ Increment 2, a separately-managed program for low-band jamming that had been planned for fiscal years 2014 and 2015, were postponed to fiscal year 2016 for funding reasons. As a result, program officials stated the Navy pushed back Increment 2's planned entry into development from fiscal year 2018 to 2020, although program officials stated this date may change as the studies progress. These design trade studies are intended to evaluate the maturity of technologies and refine requirements.

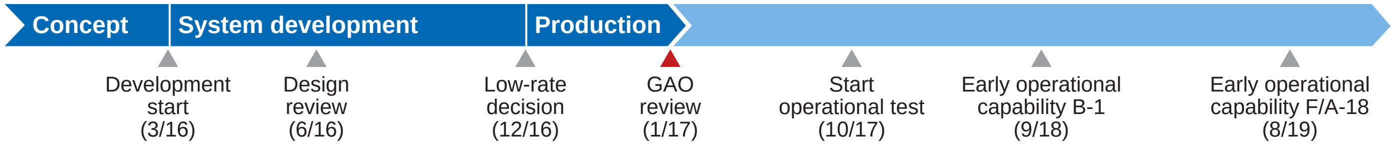
Program Office Comments

In commenting on a draft of this assessment, the NGJ program stated NGJ Increment 1 entered system development in April 2016 after successfully meeting required criteria. NGJ met required technology maturity for seven critical technologies and established a program baseline after completion of preliminary design review in October 2015. As of November 2016, the contractor had released 76 percent of the design drawings and is on track to exceed the Naval Air Systems Command best practice of 80 percent completed by critical design review. The program completed significant prototyping of key systems and subsystems prior to system development, which reduced risk to acceptable levels for system development as determined by the milestone decision authority. According to program officials, NGJ's extensive use of contractor and government systems integration labs, along with the use of test chambers to evaluate pod performance, will significantly reduce risk prior to the program’s planned start of production.

Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)

The Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1) is a Navy-led program to develop an air-launched, long-range, anti-surface warfare missile to address an urgent operational need. The program is using an accelerated acquisition approach and leveraging previous technology demonstration efforts. It plans to field an early operational capability on Air Force B-1 bombers in 2018 and Navy F/A-18 aircraft in 2019. DOD is developing specifications for Increment 2 to address the threat in 2024 and beyond. We assessed Increment 1.


Source: U.S. Navy.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Patuxent River NAS, MD
Funding needed to complete:
R&D: $494.7 million
Procurement: $341.0 million
Total funding: $835.7 million
Procurement quantity: 110

Program Performance (fiscal year 2017 dollars in millions)

	As of 03/2016	Latest 08/2016	Percent change
Research and development cost	$1,223.8	$1,154.3	-5.7%
Procurement cost	$304.4	$341.0	12.0%
Total program cost	$1,528.3	$1,495.3	-2.2%
Program unit cost	$12.325	$12.256	-0.6%
Total quantities	124	122	-1.6%
Acquisition cycle time (months)	43	42	-2.3%

The OASuW Inc 1 program received approval to enter production in December 2016 with its critical technologies mature, a stable hardware design, and demonstrated production processes. However, technology maturity has not been confirmed through independent assessment, and flight tests will not occur until after production begins. Software development challenges have delayed aspects of subsystem testing but are not assessed as presenting an overall schedule risk. The program's accelerated acquisition approach, designed to address an urgent operational need, includes concurrency between developmental testing and production, which increases the risk of late design changes and costly retrofits after production has started. The program seeks to mitigate risks by leveraging design commonalities with a missile already in production and limiting the number of missiles purchased.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	○
Manufacturing processes are mature		
	PRODUCTION START	
Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	▨	▨
Test a production-representative prototype	○	○

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

OASuW Inc 1 Program

Technology Maturity

While the most recent independent technology readiness assessment, conducted by the Navy in August 2016, assessed the program's six critical technologies are nearing maturity, in the past year, the OASuW Inc 1 program has fully matured all six of its critical technologies. The program's single, hardware-based critical technology—a radio frequency sensor—as well as five software-based ones—autorouter, low altitude control estimator, target tracker, electro-optical algorithms, and simultaneous time of arrival capbility—were demonstrated in a relevant environment. According to program officials, critical technologies were matured further through a combination of modeling and simulation and flying test bed events that did not involve launching a missile. The program office assessed all critical technologies were mature at its production start in December 2016, although this was not confirmed by an independent assessment or through missile flight tests, which are not planned to begin until the fourth quarter of fiscal year 2017.

Design Maturity

The OASuW Inc 1 hardware design is stable, but the program is addressing software and manufacturing challenges that have delayed testing used to demonstrate the design will work as intended. The program held its critical design review in June 2016, at which time all the drawings expected to support production were releasable to manufacturers. According to program officials, nearly all subsystems have been qualified, which means they have been tested to ensure that they can meet requirements, but software challenges delayed some subsystem testing. With hardware design stable, officials stated remaining software challenges can be addressed later in testing without negatively affecting the schedule. Additionally, program officials noted manufacturing challenges resulted in test unit delivery delays, but these delays are not expected to affect the program's testing schedule.

Production Maturity

In December 2016, a series of production readiness reviews found that critical production processes for OASuW Inc 1 were demonstrated in a production representative environment or on a pilot line. The system leverages the airframe and production facilities of the Joint Air-to-Surface Standoff Missile-Extended Range (JASSM-ER) program, which the program reports will decrease production risks. The program was tracking a risk related to the JASSM-ER fuze, which had not been qualified for use on Navy weapons, but its use has since been certified by the Navy. The first missiles to support an early operational capability are planned for delivery in the second quarter of fiscal year 2018.

Other Program Issues

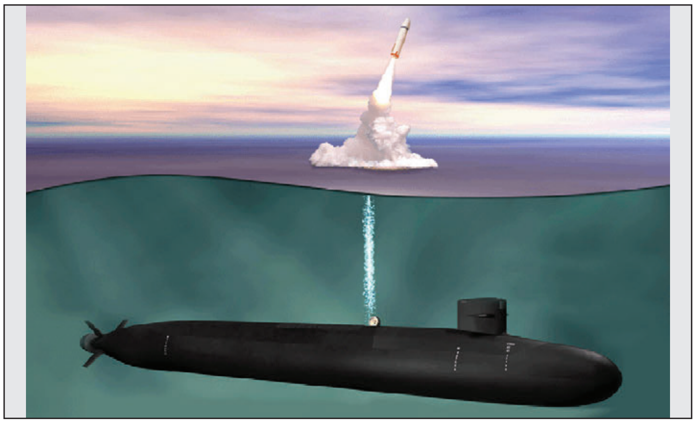
Maintaining the program's schedule is the primary concern for OASuW Inc 1, which is intended to address an urgent operational need. The program's current accelerated acquisition approach consists of decision points that align with key systems engineering reviews, test events, contract actions, and fielding decisions. The approach requires concurrency between developmental testing and initial production. Our past work has shown that beginning production before demonstrating that a design is stable and will work as intended increases the risk of discovering deficiencies during production that could require costly design changes, modifications, and retrofits. The program has accepted this risk and mitigated it, in part, by limiting the program to the 110 missiles needed to provide a capability until the second increment is fielded.

Program Office Comments

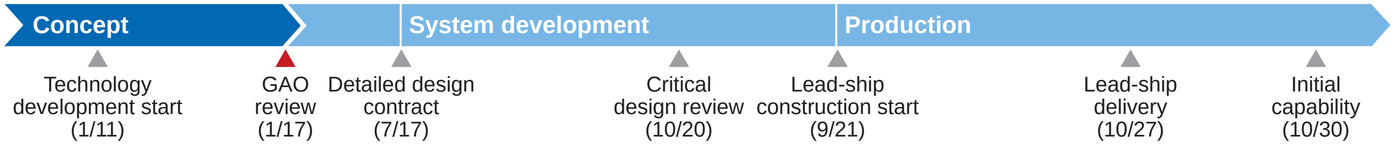
In commenting on a draft of this assessment, program officials noted OASuW Inc 1 is an accelerated acquisition program intended to fill an urgent capability requirement in the maritime domain. Accordingly, schedule is elevated as a priority with associated, increased emphasis on risk management, including those related to concurrent system test and production activities. According to the program, the hardware design is mature. Program risk assessments provide additional oversight and an executive steering board chaired by the senior Navy acquisition authority regularly reviews technical progress, facilitates risk management activities, and mitigates barriers to progress. According to the program, OASuW Inc 1 has successfully progressed from technology development through a production readiness decision in 10 months, and the program remains on track for early operational capability fielding in the fourth quarter of fiscal year 2018. The program also provided technical comments, which were incorporated where deemed appropriate.

SSBN 826 Columbia Class Ballistic Missile Submarine (SSBN 826)

The Navy's new Columbia Class (SSBN 826) will replace the current fleet of Ohio Class SSBNs as they begin to retire in 2027. The program seeks to provide affordable platforms for sea-based strategic deterrence that will remain in service through 2080. The Navy began technology development in January 2011 in order to avoid a capabilities gap between the Ohio Class's retirement and the fielding of a replacement system. The program plans to begin detail design in 2017, with lead ship construction starting in fiscal year 2021.



Source: © 2012 General Dynamics Electric Boat.



Program Essentials

Prime contractor: General Dynamics Electric Boat

Program office: Washington Navy Yard, DC

Funding needed to complete:
- R&D: $6,113.2 million
- Procurement: $87,426.5 million
- Total funding: $93,666.3 million
- Procurement quantity: 12

Program Performance (fiscal year 2017 dollars in millions)

	As of 01/2017	Latest 01/2017	Percent change
Research and development cost	$12,648.1	$12,648.1	0.0%
Procurement cost	$87,426.5	$87,426.5	0.0%
Total program cost	$100,221.9	$100,221.9	0.0%
Program unit cost	$8,351.825	$8,351.825	0.0%
Total quantities	12	12	0.0%
Acquisition cycle time (months)	232	238	2.6%

The Columbia Class program entered system development in 2017 with one critical technology that has not yet been demonstrated in a relevant environment and several other major development efforts. The Navy plans to complete detail design during this phase concurrently with efforts to reduce program cost and develop Columbia-class technologies. The Navy established an aggressive schedule for construction of the lead submarine and is working with future Columbia Class shipyards to identify production efficiencies needed to meet this goal.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DETAIL DESIGN CONTRACT AWARD	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	FABRICATION START	
• Complete basic and functional design to include 100 percent of 3D product modeling	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

SSBN 826 Program

Technology Maturity

The Columbia Class program's most recent Technology Readiness Assessment (TRA) identifies only two critical technologies—one carbon dioxide removal system and one major technical feature of the stern. The Navy has subsequently determined the carbon dioxide removal system is no longer a critical technology based on testing in a relevant environment. Only the stern feature remains as a critical technology, and the Navy does not expect to start detail design for this technology until fiscal year 2018. According to DOD's guidance for conducting TRAs, a technology is critical if it may pose major technological risk during development, particularly during the Engineering and Manufacturing Development (EMD) phase of acquisition. Prior to starting EMD, the program obtained a waiver as required by statute in order to proceed with technology that has not been demonstrated in a relevant environment. As a result, the program will continue technology development activities concurrent with detail design-this strategy is inconsistent with best practices.

Design Maturity

The Navy plans to include up to 70 percent of Virginia Class submarine parts and components in the Columbia Class design. It is also designing the Columbia Class to accommodate the existing Trident II D-5 strategic weapon system, and has already completed design work for the first article quad pack of missile tubes. The program is relying on a new three dimensional (3-D) computer model design tool, which it anticipates will produce electronic instructions in support of fabrication and assembly activities. In 2016, the design shipbuilder experienced a delay in issuing early design products due to problems with this software. According to the design shipbuilder, it has largely resolved the issue and is working to recover schedule. The program aims to complete 83 percent of the 3-D design model prior to the start of lead ship construction in fiscal year 2021.

Production Maturity

The Navy plans to award a contract to start detail design in 2017, with lead ship construction scheduled to begin in fiscal year 2021. The Navy expects to build the lead ship in 84 months with follow-on ships progressively decreasing to 70 months construction time. This schedule is aggressive, considering that it is approximately the same duration as the lead Virginia class submarine, even though the Columbia Class is over two times larger and the first ballistic missile submarine built in decades. According to the Navy, a decision in 2012 to delay construction start from 2018 to 2020 eliminated flexibility to accommodate delays during construction, given that the lead ship's first strategic deterrent patrol remains scheduled for 2030. In an effort to gain back some schedule margin, the Navy is working with the future Columbia Class construction shipyards to identify production efficiencies and is requesting funding authorities from Congress to begin some construction work prior to authorization of the lead ship. Under the Navy's current plans, the shipyards will construct two submarines per year (one Virginia Class and one Columbia Class) through the 2030s.

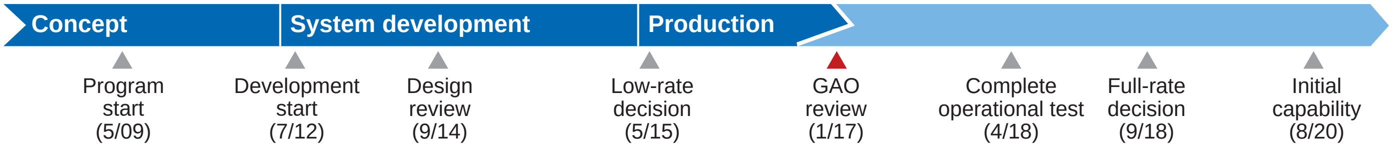
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Ship to Shore Connector Amphibious Craft (SSC)

The Navy's SSC is an air-cushioned landing craft intended to transport personnel, weapon systems, equipment, and cargo from amphibious vessels to shore. SSC is the replacement for the Landing Craft, Air Cushion, which is approaching the end of its service life. The SSC is designed to deploy in and from Navy amphibious ships with well decks, such as the LPD 17 class, and will support assault and non-assault operations. The program entered system development in July 2012 and held its low-rate production decision in May 2015.

Source: U.S. Navy.



Program Essentials

Prime contractor: Textron Inc.
Program office: Washington, DC
Funding needed to complete:
  R&D: $20.9 million
  Procurement: $3,098.4 million
  Total funding: $3,134.0 million
  Procurement quantity: 64

Program Performance (fiscal year 2017 dollars in millions)

	As of 07/2012	Latest 10/2016	Percent change
Research and development cost	$603.7	$541.1	-10.4%
Procurement cost	$3,664.0	$3,444.3	-6.0%
Total program cost	$4,287.9	$4,000.2	-6.7%
Program unit cost	$58.739	$54.798	-6.7%
Total quantities	73	73	0.0%
Acquisition cycle time (months)	135	135	0.0%

SSC's critical technology is mature and its design is stable. The program entered low-rate production in May 2015 and has experienced some delays in its production schedule. It now anticipates delivery of the initial test and training craft in August 2017, three months later than the time of our last review. According to the program, the primary cause of these delays is its propeller supplier, whose production yields have not been reliable following a 2015 fire that destroyed its plant. The program has nine craft under contract, with four already under construction. It is seeking authority to use what it calls a "block buy contract" for fiscal years 2017 through 2018. If issues requiring design changes are identified during developmental testing—not scheduled for completion until December 2017—the program could face costly rework of the craft already in production.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	●	●
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	○	○

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

SSC Program

Technology and Design Maturity

SSC's one critical technology is mature. Although the SSC's design was not stable at its design review in 2014, it has since achieved stability. The gearbox, which had shown premature wear, passed factory acceptance testing in fall 2016. However, further testing identified design issues with high speed bearings within the gearbox. A solution has been developed and will be tested by February 2017. In May 2015, the Navy's operational test agency reported that the steep angle of SSC's loading ramp may create operational hazards for certain vehicles. The program is designing a new approach ramp to mitigate this risk, but will not have an opportunity to fully assess this and other issues until developmental testing is completed in December 2017.

Production Maturity

The program entered low-rate production in May 2015 after demonstrating that all materials, manpower, tooling, and facilities were proven and available to meet the low-rate production schedule, as recommended by DOD guidance. However, according to best practices, programs should demonstrate manufacturing processes to be in statistical control prior to production start. Specifically, critical processes should be repeatable, sustainable, and consistently producing parts within the quality standards.

The program has experienced delays in its production schedule. Nine SSC craft are under contract, with four already under construction. It now expects delivery of the initial test and training craft in August 2017, a 3-month delay since our last review. Delivery of the second craft also slipped by 3 months to November 2017. According to the program, the primary cause of these delays is the supply of propellers, 12 of which are needed for each craft. A fire destroyed the manufacturer's facility in 2015 and production yield from the new facility has been unreliable, which officials stated poses risk to the SSC production schedule.

Delivery of the test craft in late 2017 will offer the first opportunity to demonstrate that the SSC design meets requirements and that no rework is needed. Testing of this craft will occur while the contractor produces eight other SSC craft. Our previous work has found that concurrent testing and production increases the risk of discovering deficiencies that could require costly design changes and modifications to units already produced.

Other Program Issues

The Navy is seeking authority from Congress to use what it calls a "block buy contract" for SSC craft in fiscal years 2017 and 2018. The program released a draft solicitation for these fiscal years in November 2016 and plans to release a final solicitation in February 2017. Because the program does not yet have authority for a block buy, the draft solicitation sought pricing for both block buy and annual procurement contracting methods. Program officials estimate the block buy would reduce costs by 3 percent compared to an annual procurement. However, the unknowns that persist in developmental testing undermine the Navy's business case for the block buy strategy. Until this testing is completed—and the program demonstrates the craft under construction are of a configuration that meets requirements—program execution is likely to be hampered, regardless of the contracting method.

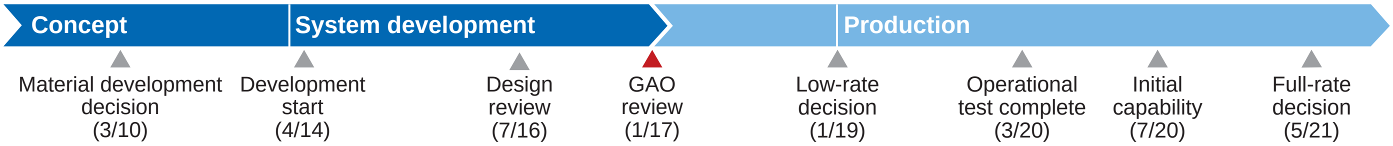
Program Office Comments

When provided with a draft of this assessment, program officials noted the following. The program is currently in the low-rate production phase. The design remains mature, and potential issues are being identified and addressed through integration and test. Currently, four craft are under construction with a fifth craft in the prefabrication stage. In addition to the items discussed in the Technology and Design Maturity section, after delays due to a fire at the manufacturer, propellers for the test and training craft are scheduled to be delivered in February 2017. The program is focused on delivering this craft in 2017 and beginning post-delivery testing in fiscal year 2018.

VH-92A Presidential Helicopter Replacement Program

The Navy's VH-92A program provides new helicopters for executive transport of the President, Vice President, heads of state, and others. A successor to the VH-71 program, which the Navy canceled due to cost growth, schedule delays, and performance shortfalls, the VH-92A will replace both legacy VH-3D and VH-60N aircraft. The VH-92A is expected to provide improved performance and communications capabilities, while offering increased passenger capacity.

Source: © Sikorsky Aircraft Corporation, a Lockheed Martin Company.



Program Essentials

Prime contractor: Sikorsky Aircraft Corp.
Program office: Patuxent River, MD
Funding needed to complete:
  R&D: $1,343.0 million
  Procurement: $2,296.6 million
  Total funding: $3,639.6 million
  Procurement quantity: 17

Program Performance (fiscal year 2017 dollars in millions)

	As of 04/2014	Latest 08/2016	Percent change
Research and development cost	$2,714.4	$2,522.2	-7.1%
Procurement cost	$2,128.0	$2,296.6	7.9%
Total program cost	$4,842.4	$4,818.9	-0.5%
Program unit cost	$210.540	$209.516	-0.5%
Total quantities	23	23	0.0%
Acquisition cycle time (months)	76	75	-1.3%

The VH-92A program completed its system-level critical design review (CDR) in July 2016 with stable designs for the VH-92A aircraft and all but one subsystem, which the contractor had not yet incorporated into its design. The program does not identify any critical technologies. The program is designing one subsystem, the mission communications system, which employs components currently in use on other platforms. The contractor identified design deficiencies with the aircraft's front and rear doors. In response, the contractor has undertaken efforts to address these deficiencies and ensure timely delivery of the development models. The program plans to enter production in 2019 prior to completing developmental testing—an approach inconsistent with best practices.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▨	▨
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▨	▨
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	○
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

VH-92A Program

Technology Maturity

The VH-92A's acquisition strategy is underpinned by use of a commercial aircraft and mature technologies to reduce the potential for problems during development and early testing. As such, the program does not identify any critical technologies. The government designed mission communications system (MCS) is the only program technology that is not in use in another system in the same configuration required for the VH-92A. First flight with a fully configured MCS is planned for June 2017. The delays in the aircraft’s build schedule caused by design revisions and availability of parts caused a 2-month delay in first flight. The MCS consists of both contractor and government furnished equipment either commercially available or already in use on other systems. According to the program office, the MCS software build is proceeding as scheduled, and updates are planned for May and October 2017, including those to address known software deficiencies associated with bandwidth and compatibility issues with ground network systems. The VH-92A program is pursuing approaches including having the MCS software be "user modifiable software," which will allow the program to modify the software and maintain compliance with the Federal Aviation Administration certification.

Design Maturity

According to the program office, the contractor released over 90 percent of VH-92A's design drawings at the time of the July 2016 CDR. These drawings represent the modifications to the baseline airframe—Sikorsky's S-92A aircraft. In addition, the program assessed designs for nearly all key subsystems and components as stable at CDR. The only exception was the Wide-band Line-of-Sight communication system, which the contractor had not yet incorporated into its design. The program has experienced a few design challenges associated with the airframe and integration. For example, the contractor has undertaken extensive design and structural analyses and studies for rear and forward air-stair efforts to ensure the VH-92A's design does not affect existing aircraft loads, which could impact its airworthiness certification and to ensure timely delivery of the development models. The MCS/CSO (Communication System Operator) interface design has also progressed slower than planned; however, the program did not experience any delays to key milestones. Currently, the contractor is prioritizing work, increasing resources to address these challenges, and is identifying areas later in the aircraft build process where cost efficiencies can be applied.

Production Maturity

The program is planning to enter low-rate initial production in January 2019, prior to completing system-level developmental testing in September 2019—an approach inconsistent with best practices. The program intends to evaluate VH-92A's readiness to enter production following an operational assessment in fiscal year 2018 and plans to demonstrate critical manufacturing processes on a pilot production line prior to entering low-rate initial production.

Other Program Issues

The Navy determined it no longer required one capability planned for VH-92A and subsequently executed a contract modification. According to program officials, as part of the related negotiation, the government and contractor agreed on an appropriate credit amount in July 2016, which the Navy will apply to other program areas.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Common Name: LX(R)

Amphibious Ship Replacement (LX(R))

The Navy’s LX(R) program plans to build a new class of ships to replace existing amphibious ships. The primary function of these ships is to transport Marines and their equipment to distant operating areas and enable expeditionary operations ashore. The LX(R) will include a larger hull than the retiring ships, and can also be used for non-combat operations due to its storage space and ability to transfer people and supplies. Starting in fiscal year 2020, the Navy plans to procure 11 ships with delivery of the first LX(R) in 2025.

Source: Computer Science Corp (CSC) pursuant to LX(R) Design Support Contract. Notional Concept LX(R).

Current Status

The LX(R) design is based on the San Antonio (LPD 17) class amphibious ships, which the Navy believes will reduce the cost risks associated with a new design by leveraging existing design stability as well as not adding any new critical technologies. However, the existing LPD 17 design is unaffordable for the LX(R) program, so the Navy is aiming to reduce costs while ensuring that the LX(R) meets the requirements validated by the Joint Staff in October 2016. The Navy used a limited competition approach that combined LX(R) design efforts with acquisition activities for the next America Class Amphibious Assault Ship (LHA 8) and the first six John Lewis Class Fleet Replenishment Oilers (T-AO 205). In 2015, the Navy issued a combined solicitation that was limited to two contractors—Huntington Ingalls Industries and General Dynamics NASSCO—for detail design and construction of T-AO 205 ships and LHA 8, as well as early design work for LX(R). In 2016, Huntington Ingalls was awarded 75 percent of the LX(R) contract design hours, and General Dynamics the remainder.

Also in 2016, Congress appropriated $250 million in advanced procurement—three years earlier than the Navy had programmed—to accelerate LX(R). Program officials said they will use those funds for long lead items like engines, which could position the Navy to begin construction early. Although the Navy still plans to award the construction contract in fiscal year 2020, it now plans to start lead ship construction in fiscal year 2021 instead of fiscal year 2022, which should accelerate delivery from fiscal year 2026 to fiscal year 2025. Despite this acceleration, the Navy has not finalized its acquisition strategy, but expects to do so in fiscal year 2017. Further, DOD delegated program oversight to the Navy, which currently anticipates LX(R) will enter the acquisition process at production in fiscal year 2018.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):

Total program: $1,886.2 billion	(fiscal years 2010-2021)
Research and development: $172.2 million	(fiscal years 2010-2021)
Procurement: $1,714 billion	(fiscal years 2016-2021)
Quantity: 11	(only one ship will be acquired between fiscal years 2016-2021)

Next Major Program Event: Release of request for proposal for long lead time materials and detail design contract award, fourth quarter fiscal year 2017

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

DDG 51 Flight III Destroyer (DDG 51 Flight III)

The DDG 51 Flight III destroyer will be a multi-mission ship designed to operate against air, surface, and subsurface threats. Compared to existing Flight IIA ships, Flight III ships will provide increased ballistic missile and area air defense capabilities to the fleet. Flight III's planned configuration changes include replacing the current SPY-1D(V) radar with the Air and Missile Defense Radar program's SPY-6 radar. The Navy plans to acquire a total of 22 Flight III ships.

Source: Huntington Ingalls Industries, Pascagoula, MS.

Current Status

The Navy continues Flight III detail design activities, which include extensive changes to the ship's hull, mechanical, and electrical systems to incorporate the SPY-6 radar and restore safety margins to the weight and stability limitations of the ship. To reduce technical risk, the Flight III design includes new electrical and air conditioning systems that are currently in use on other ship classes. The existing DDG 51-class ship design is dense and creates challenges for Flight III design and construction, such as having to rearrange equipment to fit new items and potentially higher construction costs due to inefficiencies caused by working in tight spaces. The Navy began Flight III zone design—three-dimensional modeling of the individual ship units—in October 2015 and plans to complete zone design before starting construction in spring 2018. The Navy's plans are ambitious, considering the amount and complexity of the remaining design work. For example, one shipbuilder was not scheduled to begin zone design on the five zones requiring the most complex changes until December 2016, which may provide insufficient time to discover and address problems.

The Navy planned to modify its existing Flight IIA multiyear procurement contracts to construct the first three Flight III ships. In fiscal year 2016, the Navy received $1 billion in construction funding to procure an additional ship. The Navy now plans to use this funding to acquire the first Flight III ship under a fixed price incentive engineering change proposal. The Navy is revising its Flight III acquisition strategy, including an updated acquisition program baseline and cost estimate, for an upcoming but unscheduled program review ahead of Flight III construction start.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: $43,860.4 million
Research and development: $4,082.9 million
Procurement: $39,777.5 million
Quantity: 22 (procurement)

Next Major Program Event: Award of first Flight III construction contract, fiscal year 2017.

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate. In addition, program officials noted that DDG 51 Flight III design is progressing to support the start of construction with a mature and stable design. Officials also noted that the Flight III Critical Design Review was successfully completed in November 2016 and that initial functional design and transition design are complete with zone design underway and expected to complete prior to the start of construction.

John Lewis Class Fleet Replenishment Oiler (T-AO 205) [formerly T-AO(X)]

The T-AO 205 program is intended to replace the Navy's 15 existing T-AO 187 Class Fleet Oilers, which are nearing the end of their service lives. The primary mission T-AO 205 oilers will fulfill is replenishment of bulk petroleum products, dry stores and packaged cargo, fleet freight, mail, and personnel to other vessels while underway. The Navy plans to procure a total of 17 ships, starting with the first in fiscal year 2016 and the remaining ships at a rate of one per year beginning in fiscal year 2018.

Source: U.S. Navy. Notional Concept T-AO(X)

Current Status

The Navy assessed the program's three critical technologies—all associated with a new underway replenishment system for transferring cargo to other ships—as fully mature based on the results of land-based and at-sea prototype testing. Each T-AO 205 oiler will have greater cargo capacity than legacy T-AO 187 class oilers to replenish items such as food and spare parts.

In June 2016, the Navy awarded a detail design and construction (DD&C) contract after limited competition that combined the purchases of the first 6 T-AO 205 class ships with LHA 8 and initial engineering efforts for LX(R), which are amphibious ships. The Assistant Secretary of the Navy for Research, Development, and Acquisition—the T-AO 205 program's milestone decision authority—approved a tailored acquisition approach wherein the program awarded a lead ship DD&C contract before conducting a preliminary design review (PDR). According to program officials, the program plans to conduct the PDR 12 months after award of the DD&C contract because, when adapting a commercial ship design for Navy use, some information typically evaluated in a PDR can only be determined after developing an allocated baseline, which is essentially defining all subsystems and how they will work together in the overall ship design.

Congress authorized the Navy to award what the Navy refers to as a block buy contract covering the second through sixth ships of the class. The remaining 11 ships of the class, according to Navy officials, will be acquired at a rate of one ship per year under two additional, possibly firm-fixed-price, contracts. In addition, program officials said that they are working with the prime contractor to reduce costs and have incentivized cost reduction in the lead ship DD&C contract. The program's estimated acquisition costs beyond fiscal year 2021 remain in development.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: $2,357.78 million (fiscal years 2011-2021)
Research and development: $57.78 million (fiscal years 2011-2015)
Procurement: $2,300.00 million (fiscal years 2016-2021)
Quantity: 5 (fiscal years 2016-2021)

Next Major Program Event: Preliminary Design Review, April 2017

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

MQ-25 Unmanned Aircraft System (MQ-25)

The Navy's MQ-25 will be a catapult-launched unmanned aircraft system (UAS) operating from aircraft carriers. When complete, it will provide a robust refueling capability for the carrier air wing with an intelligence, surveillance, and reconnaissance (ISR) capability. The system is made up of an air segment, a carrier segment, and a control system and connectivity segment. It is the outcome of a restructuring of the former Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) program.

Source: Jeff Hobrath, Chief, USN (Ret) President, Naval Tees, LLC.

Current Status

In February 2016, following a review of its airborne ISR portfolio, DOD restructured the UCLASS program to create the Carrier Based Aerial Refueling System, subsequently designated the MQ-25. This decision followed debate regarding the intended mission and required capabilities of UCLASS. In particular, DOD evaluated whether the system's primary role should be largely surveillance with limited strike capability or largely strike with limited surveillance capability. Ultimately, DOD elected to pursue an aerial refueling capability with some ISR capability in a newly restructured program, which the Navy included in its fiscal year 2017 budget submission. According to Navy officials, the MQ-25's aerial refueling capability will reduce the need for F/A-18E/F Super Hornet aircraft to provide refueling, freeing them for strike missions and preserving service life.

The Navy plans to release a request for proposals for air system development by summer 2017 and award a contract one year later. The Navy does not plan to conduct a system-level preliminary design review before starting development. Instead, the Navy will use knowledge gained through previously conducted reviews with the four UCLASS contractors. Additionally, in September and October 2016, the Navy awarded cost-plus-fixed-fee contracts valued between $35.8 million and $43.7 million to each of those four contractors to conduct risk reduction activities, including concept refinement and requirements trade analysis. While four critical technologies were identified for UCLASS, the Navy has not yet identified any for the MQ-25. According to Navy officials, provisions will be incorporated for potential future strike capabilities, but requirements for initial operating capability—expected by the end of fiscal year 2026—will focus on refueling and ISR capabilities.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: TBD
Research and development (fiscal years 2012-2021): $3,122 million
Procurement: TBD
Military construction (fiscal years 2012-2021): $39 million
Quantity: TBD

Next Major Program Event: Release request for proposals for engineering, manufacturing, and development of air system, summer 2017.

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Navy Frigate

The Navy's new frigate is expected to be a multi-mission small surface combatant derived from minor modifications to a Littoral Combat Ship (LCS) design. The frigate will incorporate existing surface and subsurface capabilities, and add over-the-horizon missile and electronic warfare capabilities, among other improvements. Compared to the existing LCS, the frigate is expected to provide improved lethality and survivability. The Navy plans to acquire a total of 12 frigates beginning in fiscal year 2018.

Source: Lockheed Martin (left); General Dynamics (right).

Current Status

The Navy has not yet fully defined the frigate's design and cost. Despite these uncertainties, the Navy's current acquisition strategy—approved in March 2016—indicates it intends to request authorization from Congress in 2017 to use what it calls block buy contracting to buy all of the planned frigates and for funding the lead ship before solidifying realistic cost and design parameters. This acquisition strategy includes the Navy obtaining block buy option pricing in 2017 from both LCS shipyards for 12 LCS. Then, the Navy plans to combine frigate-specific design upgrades with the LCS priced options to inform its decision on a single frigate contractor and design in July 2018. The estimated cost for the program is uncertain—the Navy expects to have a formal estimate in May 2017, and DOD's Office of Cost Assessment and Program Evaluation has indicated an independent cost estimate will be completed in fiscal year 2018.

The Navy is currently reviewing frigate build specifications received from the two LCS shipbuilders in the lead up to soliciting proposals in September 2017 for the frigate design upgrades. The Navy plans to review these proposals and award the frigate to a single shipyard before beginning detail design—a critical phase of design that more fully defines ship construction needs and cost expectations. Although the Navy has stated detail design will be completed before frigate construction begins in fiscal year 2020, awarding the contract for frigate construction before beginning frigate-specific detail design activities reduces the knowledge that will be available to help inform decisions by the shipbuilders and the Navy in the solicitation and contract award process.

Estimated Program Funding and Quantity (fiscal year 2017 dollars):
Total Program (fiscal years 2016-2025): $8,317.9 million
Research and development (fiscal years 2016-2021): $312.4 million
Procurement (fiscal years 2018-2025): $8,005.4 million
Quantity: 12

Next Major Program Event: Design Maturity Review, August 2017

Program Office Comments: In commenting on a draft of this assessment, the program office stated that the frigate will provide significant improvements in lethality and survivability. The program office also noted that, while frigate detail design will not be completed before contract award, it has been completed for any areas common with LCS, which total greater than 60 percent for both LCS variants. The program office provided technical comments as well, which were incorporated where deemed appropriate.

P-8A Increment 3

The Navy's P-8A Increment 3 is intended to provide enhanced capabilities to the P-8A aircraft in four sets of capability improvements. The first two sets include communications, radar, and weapons upgrades, which will be incorporated into the existing P-8A architecture. The second two sets will establish new open systems architecture and integrate improvements to the combat system's ability to process and display classified information and its search, detection, and targeting capabilities.

Source: U. S. Navy.

Current Status

In March 2016, the Under Secretary of Defense for Acquisition, Technology and Logistics approved an updated P-8A acquisition strategy, incorporating Increment 3 capabilities as a series of engineering change proposals to the existing program. Increment 3 will no longer be managed as a separate program as previously planned. In May 2016, the Under Secretary re-designated the P-8A as an acquisition category IC program and delegated Milestone Decision Authority to the Assistant Secretary of the Navy for Research, Development and Acquisition. The acquisition program baseline was updated to support the strategy change in June 2016.

The P-8A Increment 3 program's objective is to deliver improved capabilities while introducing competition and increasing the government's role in developing future upgrades. Program officials stated Increment 3 will require the integration of new hardware and software based on mature technologies. As a result, the program has not identified any critical technologies. The program office estimates this effort is evenly split between hardware and software. The Navy awarded sole-source contracts to Boeing—the P-8A prime contractor—to integrate capabilities into the existing aircraft in fiscal years 2018 and 2019. In fiscal years 2022 and 2023, the program office plans to deliver an application based open system architecture, which will allow it to openly compete the development and integration of the future capabilities. This architecture upgrade is being competitively prototyped and executed as an open source, collaborative development. The program office awarded two software development contracts in 2014. Program officials said they will choose the best parts of each design and integrate them into a single architecture. The hardware will be funded as a part of the operating and support costs of the P-8A.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: $1,128.91 million
Research and development: $1,128.91 million
Procurement: N/A
Quantity: 109

Next Major Program Event: Increment 3 Engineering Change Proposal 6 Preliminary Design Review, fourth quarter fiscal year 2017

Program Office Comments: In commenting on a draft of this assessment, program officials stated that the P-8A Increment 3 program continues to execute the approved acquisition strategy. This strategy includes the engineering and contract work necessary to support the efficient integration of required capabilities, as engineering change proposals into the P-8A baseline.

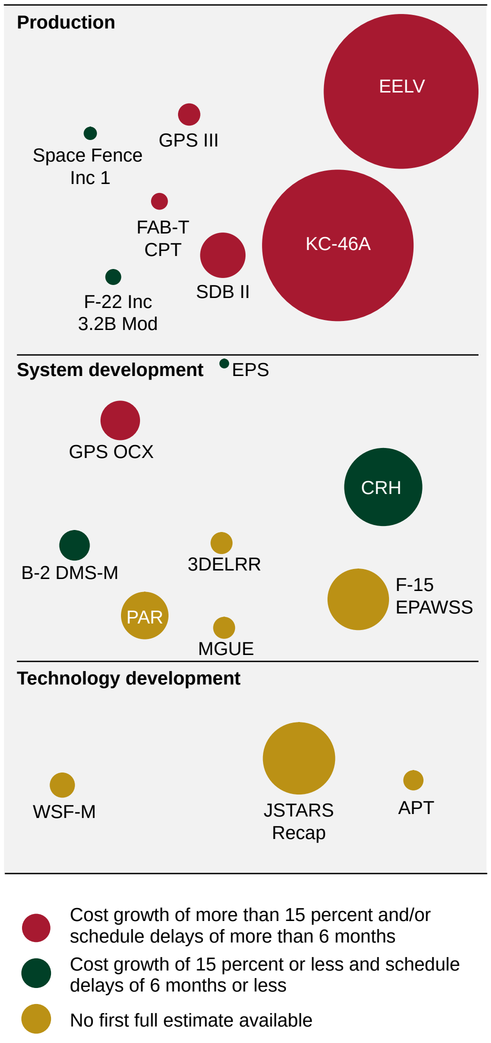
Air Force Programs Summary

We completed individual assessments on 18 of the Air Force's 32 current and future major defense acquisition programs. Of these 18 programs, 14 are, for the most part, in system development or early production, while 4 are future programs that DOD expects to enter system development in the next few years. We found the Air Force currently estimates a need of $98.2 billion in funding to complete the acquisition of these 18 programs. In addition, we compared these 18 programs' first full estimates of cost and schedule, as available, with their current estimates and found:

- net cost growth totals $39.7 billion, almost all of which occurred in the past 5 years and is attributable to the Evolved Expendable Launch Vehicle (EELV) program, and
- program schedule delays average approximately 3 months.

Further, 4 of the 18 programs—Enhanced Polar System, EELV, Small Diameter Bomb Inc II, and Space Fence Inc I—completed all activities associated with the applicable knowledge based best practices we assess, although these activities were not fully complete at the time the knowledge points were reached.

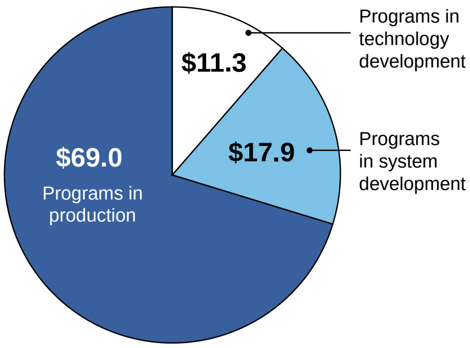
Acquisition Phase and Size of the 18 Programs Assessed



Note: Bubble size is based on each program's currently estimated future funding needed.

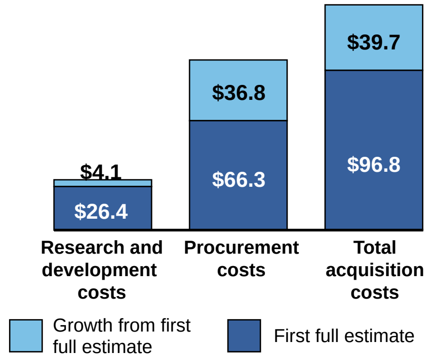
Currently Estimated Acquisition Cost for the 18 Programs Assessed

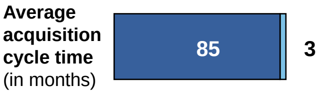
Fiscal year 2017 dollars in billions



Cost and Schedule Growth on 11 Programs in the Current Portfolio

Fiscal year 2017 dollars in billions





Note: For acquisition cycle time only 9 programs were assessed as not all programs contained sufficient information within their first full estimates to determine acquisition cycle time. In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

Program common name	Knowledge Point (KP) 1 Resources and requirements match: At KP1	Knowledge Point (KP) 1: Current Status	Knowledge Point 2 Product design is stable: At KP2	Knowledge Point 2: Current Status	Knowledge Point 3 Manufacturing processes are mature: At KP3	Knowledge Point 3: Current Status
B-2 DMS	○	○	KP 2 in future		KP 3 in future	
CRH	○	○	KP 2 in future		KP 3 in future	
EPS	●	●	- - -	●	▨	▨
EELV	- - -	●	- - -	- - -	- - -	- - -
F-15 EPAWSS	○	○	KP 2 in future		KP 3 in future	
F-22 Inc 3.2B Mod	○	●	○	●	○	○
FAB-T	- - -	○	○	●	○	○
GPS III	○	●	○	●	○	○
GPS OCX	○	○	▨	▨	KP 3 in future	
KC-46A	○	●	○	●	○	○
MGUE Inc 1	○	○	▨	▨	▨	▨
SDB II	○	●	○	●	●	●
Space Fence Inc 1	○	●	○	●	▨	▨
3DELRR	○	○	KP 2 in future		KP 3 in future	

● All applicable knowledge practices completed
○ One or more applicable knowledge practices were not completed
▨ Knowledge practice is not applicable
- - - Information not available for knowledge practice

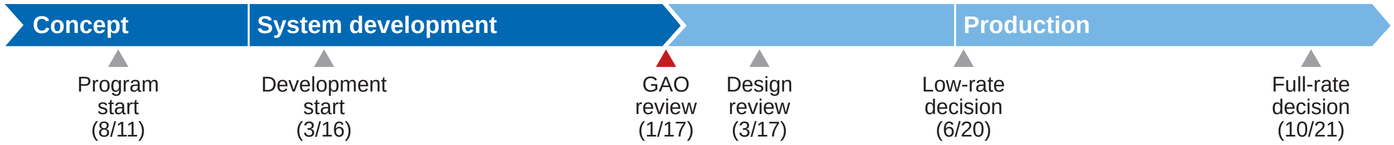
Source: GAO analysis of DOD data. | GAO-17-333SP

Air Force Program Assessments

B-2 Defensive Management System Modernization (B-2 DMS-M)

The Air Force's B-2 DMS-M program plans to upgrade the aircraft's 1980s-era analog defensive management system to a digital capability. This system detects and locates enemy radar systems to provide threat warning and avoidance information. This upgrade is expected to improve the frequency coverage and sensitivity of the system, update pilot displays, and enhance in-flight rerouting capabilities to avoid air defense threats. It also expects to improve the reliability and maintainability of the DMS system and the B-2's readiness rate.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Northrop Grumman
Program office: Wright Patterson AFB, OH
Funding needed to complete:
R&D: $820.0 million
Procurement: $747.5 million
Total funding: $1,567.5million
Procurement quantity: 16

Program Performance (fiscal year 2017 dollars in millions)

	As of 05/2016	Latest 08/2016	Percent Change
Research and development cost	$1,854.7	$1,854.7	0.0%
Procurement cost	$747.5	$747.5	0.0%
Total Program cost	$2,602.3	$2,602.3	0.0%
Program unit cost	$130.113	$130.113	0.0%
Total quantities	20	20	0.0%
Acquisition cycle time (months)	124	130	4.8%

The program entered system development in March 2016 with four critical technologies nearing full maturity, but may fall short of meeting two key performance parameters. Consistent with best practices and statutory requirements, the program completed a preliminary design review prior to development start. The program expected to complete a critical design review in December 2016, but delayed it to study hardware changes that may reduce costs. The program will not test a system level integrated prototype until after this review, and system integration challenges remain, including a precise antenna installation and calibration as well as nuclear hardening of components. Test range availability, test data turnaround times, and software development may each present challenges to meeting schedules. In addition, there are limitations to verifying the system will work as intended.

Attainment of Product Knowledge

As of January 2017

	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

B-2 DMS-M Program

Technology Maturity

The program entered system development in March 2016 with four critical technologies nearing maturity. A receiver-processor for bands 1-3 has been flight tested on another program. When the program entered the technology development phase in 2011, the other 3 technologies—band 4 antenna, band 4 receiver-processor, and geo-location algorithm—were immature with only limited demonstrations completed. The Air Force tested the fourth technology, a receiver-processor for bands 1-3 on another program. The program office subsequently refined requirements and better matched them with the maturity of the technologies. As a result, the Air Force reduced planned DMS-M capabilities, which the user determined was an acceptable trade given the additional cost and time needed to meet the more demanding requirements. The program office currently projects meeting two key performance parameters related to these technologies could be at risk, but it expects to mitigate these risks over the next 4 years prior to production start.

Design Maturity

The program expected to complete its critical design review in December 2016 with nearly 100 percent of the expected drawings released, but without testing a system level integrated prototype. However, the program office recently delayed the review to study potential hardware changes that may reduce costs. Consistent with best practices and statutory requirements, the program completed a preliminary design review prior to beginning development. The DMS-M contractor estimated over 80 percent of the software development was complete. However, technical integration challenges remain. The B-2 DMS-M is the largest and most invasive modification since the aircraft was fielded. The antenna design requires stringent tolerance limits for airframe installation due to stealth requirements and requires precise calibration. Most components require nuclear hardening to meet operating requirements. The system also requires a tightly coupled hardware and software integration to enable threat assessment and auto-rerouting for enhancing B-2 survivability.

Other Program Issues

The total estimated cost to develop and equip 20 B-2s with the DMS-M has increased about $500 million from estimates made at the start of technology development phase in 2011. The Air Force awarded a cost reimbursable type contract for system development with incentive fees tied to cost and performance. About two-thirds of the available fee is targeted at incentivizing the contractor to complete system verification, software, and test readiness events on time. If the contractor is successful, the program office predicts the estimated program cost would be reduced by $209.8 million. However, the contractor has had difficulties in meeting past schedules. Challenges remain that could impact its ability to meet the current schedule, including test range availability, test data turnaround times, and timely completion of software development.

Operational testers identified three potential limitations to verifying that the DMS-M works as intended: (1) testing in a dense signal environment will be limited to modeling and simulation; (2) determining whether the system is meeting reliability and availability requirements due to the limited number of flight test hours; and (3) testing on-aircraft cybersecurity may not be practical due to security and test asset concerns.

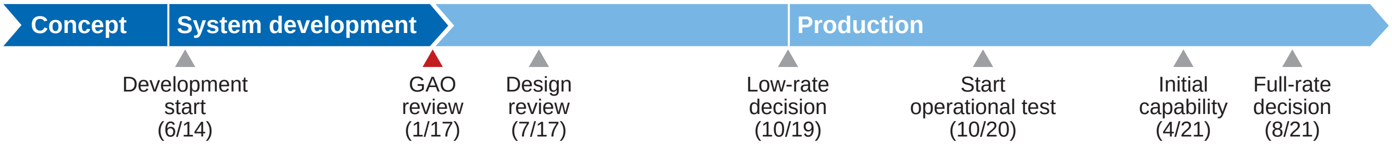
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Combat Rescue Helicopter (CRH)

The Air Force's Combat Rescue Helicopter (CRH) is intended to recover personnel from hostile or denied territory as well as conduct humanitarian, civil search and rescue, and disaster relief. The CRH is intended to replace aging HH-60G Pave Hawk helicopters with a derivative of the operational UH-60M helicopter. Planned modifications to the commercial design include a new mission computer and software, a higher capacity electrical system, larger capacity main fuel tanks, armor for crew protection, and situational awareness enhancements.

Source: ©2015 Sikorsky Aircraft Corporation. Used with permission for support of CRH.



Program Essentials

Prime contractor: Sikorsky Aircraft Corporation
Program office: Wright Patterson AFB, OH
Funding needed to complete:
- R&D: $1,480.6 million
- Procurement: $6,614.9 million
- Total funding: $8,122.6 million
- Procurement quantity: 103

Program Performance (fiscal year 2017 dollars in millions)

	As of 06/2014	Latest 08/2016	Percent change
Research and development cost	$2,040.2	$2,040.8	0.0%
Procurement cost	$6,362.3	$6,614.9	4.0%
Total program cost	$8,427.1	$8,682.9	3.0%
Program unit cost	$75.242	$77.526	3.0%
Total quantities	112	112	0.0%
Acquisition cycle time (months)	75	82	9.3%

Following system development start in 2014, the CRH program completed a preliminary design review and technology readiness assessment in 2016, which identified the radar warning receiver technology as immature. Until this technology matures, the program's plan to achieve design stability by its 2017 critical design review (CDR) remains at risk. Additional knowledge gaps will persist after CDR given the program's plans to defer early prototype testing to 2018 and finish software development in 2020 after production begins in 2019. The program also plans for critical manufacturing processes to be in statistical control and to test a production representative prototype before the start of production in line with best practices.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	○
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

CRH Program

Technology Maturity

The CRH program began system development in 2014 without identifying and assessing the maturity of its critical technologies. At the program's milestone review for entry into system development, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) waived the technology maturity requirements, citing the maturity of the program's technologies. Program officials said in 2016, however, the program completed an independent technology readiness assessment, which identified the one critical technology, the radar warning receiver, was immature. While an analog version currently functions on other military helicopters, it will require additional technology maturation for use on the CRH as a digital system providing threat warnings and situational awareness.

Design and Production Maturity

The CRH program conducted its preliminary design review (PDR) in April 2016, almost 2 years after system development started—an approach inconsistent with best practices. USD AT&L waived the statutory requirement for earlier completion of the PDR. Although program officials said no significant risks or issues were identified for the CRH program, they are tracking several moderate risks, including some related to aircraft weight.

As of August 2016, the program had released about 84 percent of the expected drawings and estimated 90 percent would be released by the July 2017 CDR. Achieving this 90 percent metric by CDR would be consistent with best practices, but design stability remains at risk until the radar warning receiver technology matures. In addition, the CRH program does not plan to demonstrate an early system prototype before CDR, which is inconsistent with best practices. Instead, the program plans to complete a prototype demonstration about 7 months after CDR in February 2018 and finish software development in 2020, after production is already underway.

Program officials stated system prototype testing at CDR is not needed for CRH since the program is modifying and enhancing an existing helicopter, the UH-60M, by integrating mature subsystems and associated software into this platform. However, the integration of these subsystems and software could be challenging and present some risks that must be successfully mitigated to achieve the desired capability. In our previous work, we found that when acquisition programs demonstrate technology and design maturity at appropriate points, they typically have better cost and schedule outcomes. Program officials stated they have planned for a sufficient amount of developmental testing to reduce these risks. Systems integration laboratory testing will begin in February 2017, several months before the CDR, although this testing will use partial system configurations.

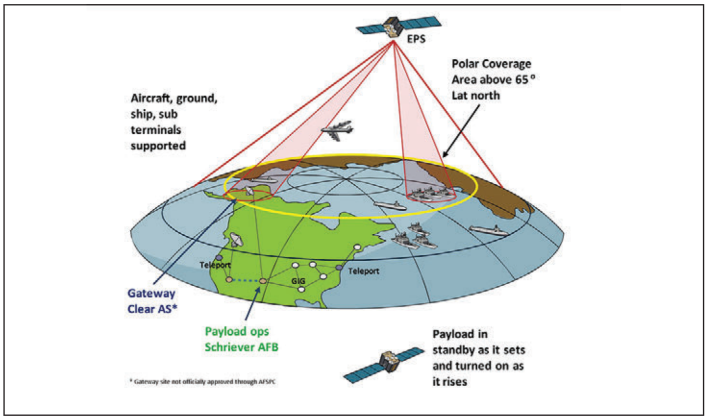
The program plans to make use of several other knowledge-based practices prior to its CDR, including identifying critical manufacturing processes and completing failure modes and effects analysis to increase confidence in the stability of the CRH design and mature its production processes. The program also plans for critical manufacturing processes to be in statistical control and to test a production representative prototype before the start of production, which is consistent with best practices.

Program Office Comments

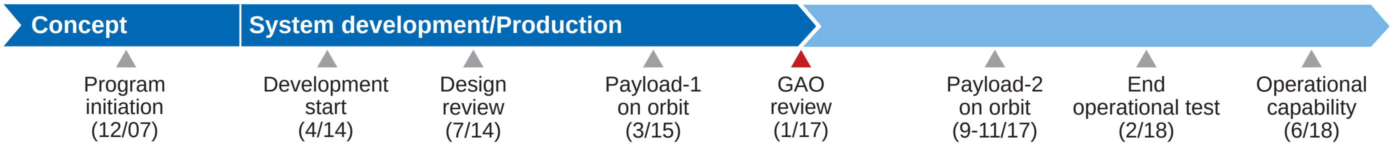
Program officials acknowledged software development could continue through the end of developmental test and evaluation in early 2020, but full capability is expected by CRH's initial test readiness review in 2018. Therefore, the only software development planned after 2018 will be to address any flight test anomalies, and program officials believe this will reduce the possibility of changes being needed during production in 2019. Testing to prove the technology maturity of the radar warning receiver in a relevant environment is planned to occur prior to the critical design review in 2017. To reduce the risk of an unsuccessful test, the Air Force Research Laboratory provided a test station to the radar warning receiver developer that will allow for up to 4 months of early risk reduction testing.

Enhanced Polar System (EPS)

The Air Force's Enhanced Polar System (EPS) will provide protected, next-generation extremely high frequency (EHF) satellite communications in the polar region. It will replace the current Interim Polar System and serve as a polar adjunct to the Advanced EHF (AEHF) system. EPS consists of three segments: two EHF payloads hosted on classified satellites, a Control and Planning Segment (CAPS), and a gateway to connect modified Navy Multiband Terminals to other communication systems.



Source: LinQuest Corporation.



Program Essentials

Prime contractor: Northrop Grumman
Program office: El Segundo, CA
Funding needed to complete:
  R&D: $73.8 million
  Procurement: $0.0 million
  Total funding: $73.8 million
  Procurement quantity: 0

Program Performance (fiscal year 2017 dollars in millions)

	As of 04/2014	Latest 10/2016	Percent change
Research and development cost	$1,446.8	$1,430.4	-1.1%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$1,446.8	$1,430.4	-1.1%
Program unit cost	$723.414	$715.186	-1.1%
Total quantities	2	2	0.0%
Acquisition cycle time (months)	126	126	0.0%

The EPS program entered development in April 2014. The three segments of EPS—payloads, CAPS, and the gateway—are in various stages of completion with mature technologies and a stable design. The EPS program's two EHF payloads are built; the first is onorbit and the second will be available for on-orbit testing in fall 2017. The gateway site installation is complete and testing was completed in December 2015. CAPS completed software development in October 2015, but implementation of cybersecurity updates delayed delivery of the segment to April 2017. CAPS delays have pushed the expected completion of on-orbit inter-segment testing, which will test all three system elements together, from August 2016 to July 2017. Operational testing is scheduled for completion in 2018 and is the last significant event scheduled, as there are no production related decisions for the program.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▒	▒
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▪▪▪▪	●
• Test a system-level integrated prototype	●	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▒	▒
• Demonstrate critical processes on a pilot production line	▒	▒
• Test a production-representative prototype	▒	▒

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▒ Not applicable

EPS Program

Technology and Design Maturity

The EPS program formally entered development in April 2014 with all critical technologies for the payload segment mature or approaching maturity. These technologies are now fully mature. In July 2014, the program held a system-level critical design review, but the program was unable to provide the number of engineering drawings to us for our prior assessments. Our current assessment shows all drawings have been released, indicating a stable design. All three segments of the program will be completed under a development effort, and there will be no production-related decisions for this program.

Both payloads are built. The first payload is on-orbit and the second payload is integrated into the host satellite and is expected to be available for on-orbit testing in fall 2017. According to program officials, all EPS hardware development and critical technologies are associated with the payloads, but the CAPS segment is the program’s critical path.

The only development work remaining within the program is CAPS. According to program officials, CAPS is primarily a software development effort and utilizes commercial off-the-shelf hardware. Program officials said CAPS software development was completed in October 2015, but implementation of cybersecurity updates has required restructuring of the CAPS schedule, delaying segment delivery to April 2017. DOD updates cybersecurity standards quarterly, which program officials stated makes it difficult to keep pace with ever-increasing security requirements while in software development. According to program officials, these requirements are described in detail via the Security Technical Implementation Guidelines programs must implement, the majority of which—along with associated verification—must occur manually, which can be time and labor intensive.

The gateway segment primarily involves integration of existing equipment and is considered low risk by the program office. Integration includes commercial off-the-shelf hardware, such as routing and switching equipment, and terminals developed under other programs. The Navy's Space and Naval Warfare Systems Command, Systems Center Pacific and MIT/Lincoln Laboratory are responsible for integrating, testing, and installing the gateway segment. Site installation for the gateway is complete, and testing was completed in December 2015. System-level on-orbit inter-segment interface testing of the payload, gateway, and CAPS was initially scheduled for completion in August 2016, but the updated CAPS schedule has delayed completion until the end of July 2017.

Other Program Issues

In our prior assessment, we reported initial operational capability was delayed from fiscal year 2016 to 2018—a timeline that now includes meeting both initial and full operational capability milestones. The program office considers implementation of cybersecurity updates to be low risk in terms of technical success, but medium risk in terms of schedule margin for system-level testing, which could further delay operational capability since the updates are changing critical path activities leading up to on-orbit testing.

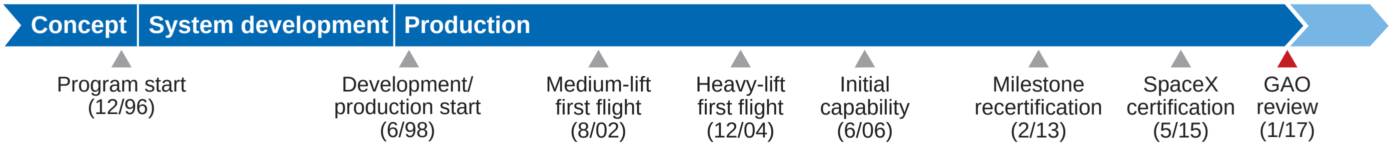
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Evolved Expendable Launch Vehicle (EELV)

EELV provides spacelift support for DOD, national security, and other government missions. Currently, the United Launch Alliance (ULA) and Space Exploration Technologies Corporation (SpaceX) are the only certified providers of EELV launch services. SpaceX's Falcon 9 was certified to compete for national security launches in May 2015 and won a GPS III launch services contract in April 2016. ULA provides launch services for EELV using two families of launch vehicles, Atlas V and Delta IV. We assessed ULA 's and SpaceX's vehicle variants.

Source: United Launch Alliance and SpaceX.



Program Essentials

Prime contractor: United Launch Services, LLC
Program office: El Segundo, CA
Funding needed to complete:
  R&D: $1,181.6 million
  Procurement: $30,532.8 million
  Total funding: $31,714.3 million
  Procurement quantity: 77

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/1998	Latest 12/2015	Percent change
Research and development cost	$1,931.3	$4,170.4	115.9%
Procurement cost	$16,917.1	$55,467.3	227.9%
Total program cost	$18,848.4	$59,637.7	216.4%
Program unit cost	$104.135	$370.421	255.7%
Total quantities	181	161	-11.0%
Acquisition cycle time (months)	NA	114	NA

We assessed the EELV's technology and found it to be mature with 102 successful launches as of January 15, 2017. EELV's design and production maturity were not assessed using our best practices, but instead using an Aerospace Corporation measure developed for the program. Using this measure, 12 of the 15 EELV launch vehicle variants offered by ULA demonstrated design maturity, as has SpaceX's Falcon 9. EELV is currently assessing options for an alternative to the Russian-made RD-180 engine used on the Atlas V vehicle, and is investing in technology development with industry through agreements utilizing DOD's "other transaction" authorities. ULA phased out the Delta IV intermediate launch vehicle, which ULA plans to discontinue by fiscal year 2018 due to its high price.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▪▪▪▪	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▪▪▪▪	●
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▪▪▪▪	▪▪▪▪
• Test a system-level integrated prototype	▪▪▪▪	▪▪▪▪
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▪▪▪▪	▪▪▪▪
• Demonstrate critical processes on a pilot production line	▪▪▪▪	▪▪▪▪
• Test a production-representative prototype	▪▪▪▪	▪▪▪▪

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

EELV Program

Technology, Design, and Production Maturity

Fourteen of 15 EELV variants offered by ULA, and the Falcon 9 from SpaceX, have flown at least once, demonstrating technology maturity. For design stability and production maturity, launch vehicles are assessed using the "3/7 reliability rule" developed by the Aerospace Corporation. Once a variant is launched successfully three times, its design can be considered stable and mature. Similarly, if a variant is successfully launched seven times, both the design and production process can be considered mature. Twelve of the ULA variants have achieved design stability, and 4 have reached both design stability and production maturity, although some variants are used infrequently and may never reach design stability or production maturity. The Falcon 9 v1.1 achieved both design stability and production maturity, and a new variant—the Falcon 9 Upgrade, which SpaceX intends to use going forward for EELV launch service competitions—first flew in December 2015 and was certified for EELV launches in January 2016. New variants introduce changes to the original design which, until proven through multiple successful flights, pose potential cost and schedule risks.

Other Program Issues

The National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2015 prohibited, with certain exceptions, the award or renewal of a contract for the procurement of property or services for space launch activities under the EELV program if such contract carries out such activities using rocket engines designed or manufactured in the Russian Federation. The NDAAs for fiscal years 2016 and 2017 amended the exceptions to the prohibition. In early 2016, the Air Force awarded agreements, utilizing DOD's "other transaction" authorities, for rocket propulsion systems.

ULA is phasing out its Delta IV Intermediate class of vehicles to make way for its new Vulcan launch vehicle currently in development with an initial capability expected, according to industry-stated timelines, in 2019. According to the program office, because the NDAA for Fiscal Year 2017 further amended the exceptions to the limitations in the NDAA for Fiscal Year 2015 to allow certain contracts to include the use of a total of 18 rocket engines designed or manufactured in Russia, the Air Force may be able to avoid a gap in launch capability for national security space launch missions. However, Air Force officials stated they consider these industry-stated rocket propulsion system timelines aggressive and optimistic.

The Air Force intends to procure three Delta IV Heavy-launch vehicles to support near-term national security launch requirements. However, while ULA has enough components to support these missions, if additional missions are required, some components are not available from suppliers and will require new ones. The use of components from new suppliers could require substantial testing, certification, and additional cost. According to the Air Force, the initial demonstration launch for SpaceX's Falcon Heavy is likely to take place in 2017.

The Air Force is developing an acquisition approach which supports two launch providers that can perform national security launches and also compete for commercial and civil government launches. Implementing this strategy may prove challenging as the demand for national security launches is expected to decline and providers will have to rely more heavily on civil government and commercial launches. Additionally, national security-unique requirements, such as additional lift capability, larger satellites, and increased structural capability for heavy payloads, can drive up costs. At the same time, commercial satellites do not require the same national security launch capability.

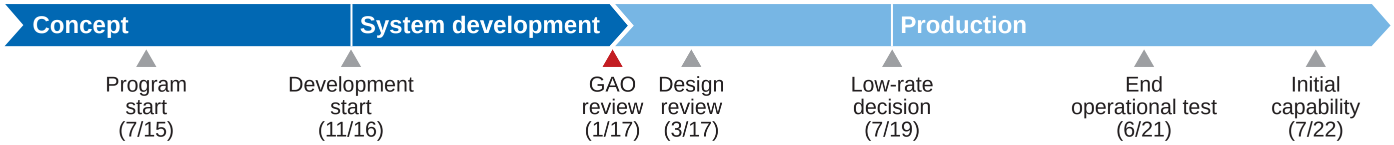
Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

F-15 Eagle Passive/Active Warning and Survivablity System (F-15 EPAWSS)

The Air Force's F-15 EPAWSS program is developing a new electronic warfare system for fielded F-15C/E aircraft. The design of this upgraded system leverages components currently in use on other military aircraft that will enhance the F-15's ability to identify and neutralize advanced air and ground threat systems. Using an incremental acquisition approach, the Air Force will replace the aircraft's legacy system with EPAWSS in Increment 1 and add a new towed decoy and associated countermeasures in Increment 2. We assessed Increment 1.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Boeing
Program office: Wright Patterson AFB, OH
Funding needed to complete:
  R&D: $786.7 million
  Procurement: $4,228.7 million
  Total funding: $5,015.4 million
  Procurement quantity: 403

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 08/2016	Percent change
Research and development cost	NA	$1,028.2	NA
Procurement cost	NA	$4,228.7	NA
Total program cost	NA	$5,256.9	NA
Program unit cost	NA	$12.729	NA
Total quantities	NA	413	NA
Acquisition cycle time (months)	NA	84	NA

F-15 EPAWSS entered system development in November 2016 with its critical technologies approaching full maturity. The program did not conduct competitive prototyping, but consistent with best practices and statutory requirements, it did hold a preliminary design review before development start that validated the use of components from other military aircraft with many of them requiring little change. At the March 2017 critical design review, the program will focus on the components that require some hardware and software development. The program plans to attain the recommended level of manufacturing readiness, complete pilot production line demonstrations, and complete an operational assessment with production representative hardware all before production start in 2019, but some developmental testing and software design work remains to be completed after this point.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

F-15 EPAWSS Program

Technology and Design Maturity

F-15 EPAWSS entered system development in November 2016 after testing by an independent review team demonstrated its four critical technologies as approaching full maturity in an operationally relevant, high-density radio frequency signal environment. Although best practices recommend fully maturing critical technologies to final form, fit, and function and demonstrating them in a realistic environment by development start, the program does not plan to attain this until 2018, leaving it at risk for flight test delays if the technologies do not function as planned. In 2015, the prime contractor for EPAWSS system integration, Boeing, competitively selected BAE Systems to develop the electronic warfare system, but competitive prototyping of an EPAWSS design was not conducted due to the leveraging of non-developmental components by the offerors, which DOD determined minimized the potential benefits of early system prototyping.

Consistent with best practices and statute, the program held a preliminary design review with Boeing before system development as well as other engineering reviews with Boeing and key sub-contractors. These reviews validated the program's strategy to leverage components from other military aircraft in a new design. Increment 1 consists of three key subsystems that will be replaced on the F-15—the radar warning receiver, electronic countermeasure processer, and countermeasure dispenser system. The program tracks design drawing estimates for both the EPAWSS hardware and aircraft changes needed to replace the legacy system with EPAWSS. According to program officials, a significant portion of the EPAWSS design is stable with many of the components requiring little or no change from a similar system already fielded on a foreign military F-15. Program officials stated the March 2017 critical design review will focus on the integration of updated subsystem components that require some hardware and software design work.

Production Maturity

Before production begins, the program plans to reach the level of manufacturing readiness for production start recommended by best practices and demonstrate critical manufacturing processes on a pilot production line to provide assurance quality requirements will be met. The program also plans to complete ground testing and a flight test based operational assessment of production representative hardware to ensure the system performs as planned before making a production start decision in 2019. However, some software development will take place after this point with about half of the developmental flight testing to be completed during production, leaving some risk EPAWSS might require unforeseen design or software changes due to performance shortfalls discovered late in testing.

Other Program Issues

To date, the Air Force has only funded Increment 1 of the program, but currently plans to request funds for Increment 2 development beginning in fiscal year 2018. Air Force officials assessed the new Increment 2 hardware and technology as mature, but it is not yet qualified for use on the F-15. In the event that the Air Force does not receive funding for Increment 2 development and production, program officials stated that the Increment 1 upgrade alone is a viable improvement to the F-15, as the legacy system it replaces is becoming functionally obsolete and unsustainable.

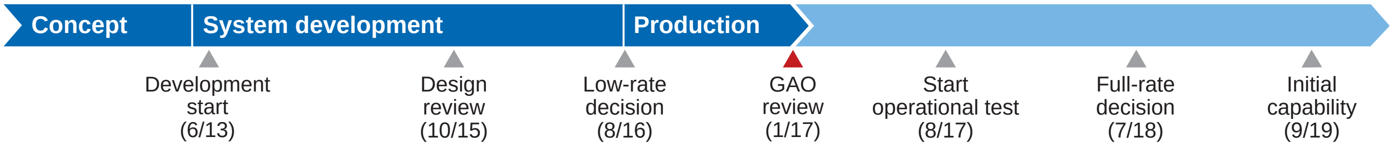
Program Office Comments

According to Air Force officials, the program is on-track in implementing a strategy to leverage mature non-developmental components as a key element of the program's efforts to drive positive schedule, affordability, and risk outcomes. They also noted the program successfully demonstrated the critical technologies needed to perform against advanced threats in a high fidelity, operationally relevant environment. Air Force officials state this demonstration greatly reduced technology risks and informed the preliminary design review as well as the November 2016 decision to enter into system development. The program's acquisition strategy enables the Air Force to continue testing EPAWSS early in system development to inform the critical design review and to ensure system maturity in time to meet the required entry criteria for the low-rate production decision, which includes completing an independent operational assessment of EPAWSS performance.

F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)

The Air Force's F-22 Raptor is a stealthy air-to-air and air-to-ground fighter/attack aircraft. The Air Force established an F-22 modernization and improvement program in 2003 to add enhanced air-to-ground, information warfare, reconnaissance, and other capabilities, and to improve the reliability and maintainability of the aircraft. Increment 3.2B, the fourth increment of the modernization program, was initially managed as part of the F-22 baseline program, but is now managed as a separate major defense acquisition program.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Wright Patterson AFB, OH
Funding needed to complete:
  R&D: $69.5 million
  Procurement: $271.0 million
  Total funding: $340.4 million
  Procurement quantity: 108

Program Performance (fiscal year 2017 dollars in millions)

	As of 06/2013	Latest 08/2016	Percent change
Research and development cost	$1,268.0	$1,179.4	-7.0%
Procurement cost	$357.5	$365.0	2.1%
Total program cost	$1,625.5	$1,544.5	-5.0%
Program unit cost	$10.694	$10.161	-5.0%
Total quantities	152	152	0.0%
Acquisition cycle time (months)	72	75	4.2%

Increment 3.2B entered production in August 2016 with its one critical technology, a geolocation algorithm, mature and its design stable. Prior to production start, the program office met DOD criteria for manufacturing readiness but did not demonstrate manufacturing processes to be in statistical control, which is inconsistent with best practices. According to program officials, flight testing will conclude in June 2017, 6 months later than expected due to reduced test range availability, which may result in some cost growth. The program is using an iterative software development process with 13 releases of capability, which is 3 more than initially planned.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	○	○
• Test a production-representative prototype	○	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

F-22 Inc 3.2B Mod Program

Technology and Design Maturity

The program's sole identified critical technology, a geolocation algorithm, is mature as it has been flight qualified in a realistic environment. According to program officials, the 3.2B program will complete flight testing in June 2017. The program demonstrated design stability prior to the October 2015 critical design review (CDR) by releasing 98 percent of its drawings. Currently, the program has released 100 percent of its system level drawings. The CDR was a culmination of multiple incremental CDRs, with the October 2015 review focused on software as the program had already completed its hardware reviews.

According to program officials, the 3.2B program intends to continue flight testing an integrated, system level prototype through June 2017, but has encountered challenges accessing adequate test facilities. The program is using an iterative software development process where 10 software releases were planned. However, due to interface issues, the program added 3 additional software releases, for a total of 13. Program officials stated these releases were only for lab use, but may add some cost and additional time to the program’s schedule.

Production Maturity

The Principal Deputy Assistant Secretary of the Air Force (Acquisition and Logistics) approved Increment 3.2B for production in August 2016, 2 months later than planned, after implementing a production readiness plan and completing qualification testing for the program's hardware components. The program office conducted an assessment of the production readiness in April 2016, finding 95 percent of critical manufacturing processes met the DOD standard for entering production. However, the contractor did not demonstrate manufacturing processes to be in statistical control prior to production start, which is inconsistent with best practices.

Other Program Issues

Program officials stated flight test delays are driven by reduced test facility availability, and noted delays in the F-35 test program have impacted test range availability for F-22 Inc. 3.2B. Program officials anticipate these delays will result in some cost and schedule growth. Program officials stated all F-22 Increment 3.2B modifications will be completed by contractor field teams at operating bases, which they believe is a more cost effective approach than depot-level maintenance. Depot-level maintenance is typically for major maintenance and repairs, such as overhauling, upgrading, or rebuilding parts, assemblies, or subassemblies, and is usually performed at a facility known as a depot.

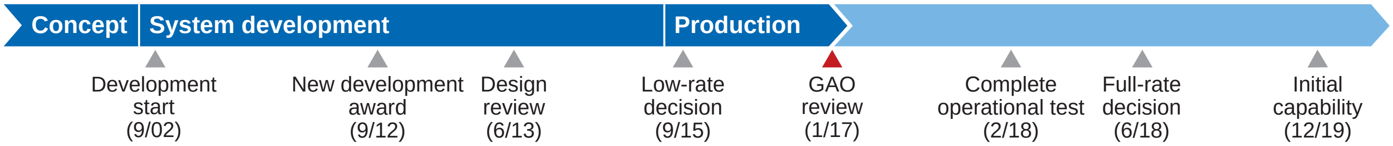
Program Office Comments

The program office was provided with a draft of this assessment and did not have any comments.

Family of Advanced Beyond Line-of-Sight Terminals Command Post Terminals (FAB-T CPT)

The Air Force's FAB-T program plans to provide a family of satellite communication terminals for airborne and ground-based users to replace many legacy communication terminals. The FAB-T command post terminals (CPT) subprogram is expected to provide voice and data communications over military satellite networks for nuclear and conventional forces through ground command posts and E-6 and E-4 aircraft. Another subprogram is expected to provide force element capabilities on B-2, B-52, and RC-135 aircraft. We assessed the CPT subprogram.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Raytheon
Program office: Bedford, MA
Funding needed to complete:
  R&D: $14.4 million
  Procurement: $350.3 million
  Total funding: $364.7 million
  Procurement quantity: 45

Program Performance (fiscal year 2017 dollars in millions)

	As of 12/2007	Latest 09/2016	Percent change
Research and development cost	$716.1	$1,175.3	64.1%
Procurement cost	$962.4	$637.6	-33.8%
Total program cost	$1,678.5	$1,812.9	8.0%
Program unit cost	$17.669	$16.632	-5.9%
Total quantities	95	109	14.7%
Acquisition cycle time (months)	129	207	60.5%

While the technologies for 22 initial FAB-T units appear mature, testing remains to be done to mature technologies for final configurations using new antennas and it is unclear whether FAB-T's design will remain stable. The Air Force expects to receive its first deliveries in 2017, but these initial units will eventually require retrofitting with new antennas. According to officials, issues discovered during testing and their resolution resulted in delays in maturing and stabilizing the new antenna configurations. The program expects to begin production of one of three new configurations in spring 2017, while the remaining two configurations will not be ready until the end of 2017. The program is conducting a cost and capability analysis for the force element terminals subprogram.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	▪▪▪▪	○
• Demonstrate all critical technologies in form, fit and function within a realistic environment	▪▪▪▪	○
• Complete a system-level preliminary design review	▪▪▪▪	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	○	○

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

FAB-T CPT Program

Technology and Design Maturity

While FAB-T entered system development in 2002, the Air Force selected a new contractor to begin development in 2012. According to the program, technologies used for the first two lots of low-rate production units are now mature, but it is unclear whether the final design is stable. The initial units use fully functional modification kits for existing antennas but will eventually be retrofitted as technologies for new antennas are not yet mature. The program expected the new antennas to be fully mature prior to the second lot procurement decision, but delays continue. Officials attributed these delays to developmental testing issues. While testing the new antenna designs, the program reported a significant number of drawing increases, which indicates design instability. Going forward, program officials told us further design changes are possible for the new antennas while they are completing developmental testing.

Production Maturity

FAB-T received verbal approval to begin production in September 2015, followed by a formal acquisition decision in October 2015. At the time, FAB-T had not met best practice standards for beginning production, but, according to the program, it met DOD's standards. The program ordered 10 modification kits in September 2015 and 12 modification kits in July 2016. As of September 2016, the contractor had assembled eight terminals; however, issues identified in first article testing have delayed deliveries until 2017. According to officials, they expect one of three new antenna configurations—for fixed ground-based platforms—to be ready for production in spring 2017, at which time they may also purchase additional modification kits for existing airborne antenna. Officials do not expect the final two configurations—new antennas for airborne and transportable ground-based platforms—to be ready until the end of 2017.

FAB-T is authorized to purchase more than 60 percent of its total units during low-rate production. Generally, programs must provide a rationale if low-rate production quantities will exceed 10 percent of total quantities. Officials said these units are required to demonstrate initial operational capability by the end of 2019.

Other Program Issues

In July 2015, DOD separated the FAB-T program into two subprograms: CPT and force element terminals (FET). Currently, only the CPT subprogram is in development and production. In July 2016, the Air Force submitted a strategy for achieving the FET requirements to the Secretary of Defense. In September 2016, the program began a cost and capability analysis, which it expects to complete by September 2017. Until the FET subprogram is executed, FAB-T cannot achieve its planned capabilities that are based on the interaction of bomber aircraft with intelligence, surveillance, and reconnaissance aircraft and CPTs.

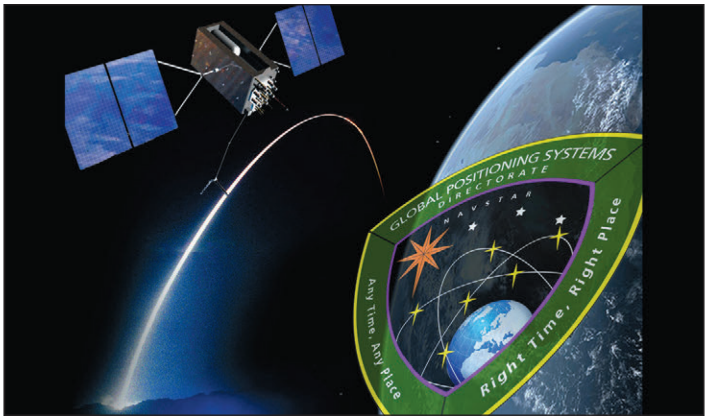
FAB-T is designed to communicate through the Advanced Extremely High Frequency (AEHF) network of satellites. Since FAB-T is not yet fielded while three of these satellites have already been launched, the lack of synchronization between the two programs has resulted in the underutilization of these costly satellite capabilities. By the time FAB-T achieves initial operational capability in 2019, one of the AEHF satellites will have been operating for nine years, over half of its projected 14-year operational lifetime.

Program Office Comments

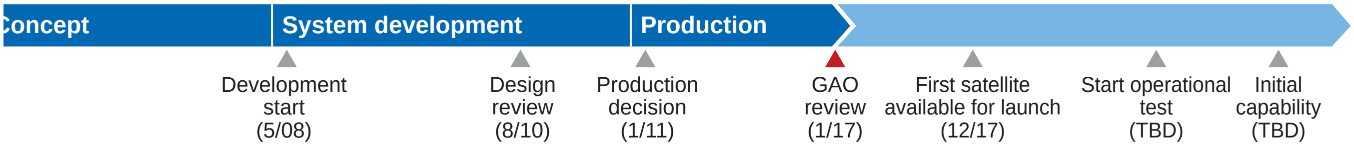
FAB-T officials stated the contractor continues development of the new ground fixed, ground transportable, and airborne antennas, and augments its workforce as needed by adding subject matter experts to address technical issues. Although the program has experienced delays in development of the new antennas, it has achieved success in government-led risk reduction testing. A FAB-T terminal was operated by space operations personnel in successful execution of over-the-air satellite telemetry, tracking, and control testing. All test objectives were successfully completed, which included all required active command functions for control of Milstar and AEHF satellites. In addition, the program office performed a series of free-field high-altitude electromagnetic pulse events simulating 68 nuclear air bursts, demonstrating the FAB-T will operate through electromagnetic effects. The program continues to actively visit sites in preparation for fielding FAB-T terminals in 2017.

Global Positioning System III (GPS III)

The Air Force's Global Positioning System (GPS) III program plans to develop and field a new generation of satellites to supplement and eventually replace the GPS satellites currently in use. Other programs are developing the related ground system and user equipment. GPS III is intended to provide capabilities for a stronger military navigation signal to improve jamming resistance and a new civilian signal that will be interoperable with foreign satellite navigation systems.



Source: U.S. Air Force.



Program Essentials

Prime contractor: Lockheed Martin
Program office: El Segundo, CA
Funding needed to complete:
- R&D: $183.7 million
- Procurement: $476.3 million
- Total funding: $660.1 million
- Procurement quantity: 0

Program Performance (fiscal year 2017 dollars in millions)

	As of 05/2008	Latest 09/2016	Percent change
Research and development cost	$2,738.0	$3,225.6	17.8%
Procurement cost	$1,537.2	$2,512.6	63.5%
Total program cost	$4,275.2	$5,738.3	34.2%
Program unit cost	$534.401	$573.827	7.4%
Total quantities	8	10	25.0%
Acquisition cycle time (months)	NA	NA	NA

We could not calculate acquisition cycle times for the first increment of the GPS III program because initial operational capability will not occur until satellites from a future increment are fielded.

The GPS III program currently reports mature technologies and a stable design, but manufacturing processes are not yet in statistical control. After a January 2016 rebaseline of the program's cost and schedule, the program identified deficiencies with subsystem components, which have contributed to new delivery delays of satellite equipment. The program has taken steps to mitigate these and other deficiencies, but now projects the first satellite's “available for launch” date will be delayed from August 2016 to February 2017 and additional delays are likely for the next seven satellites. Further, following extensive delays to the GPS III ground system—the Next Generation Operational Control System (OCX)—the Air Force now plans to accept delivery of the first eight satellites before operational testing confirms the satellite’s modernized signal capabilities.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
Demonstrate all critical technologies in form, fit and function within a realistic environment	▨	▨
Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
Release at least 90 percent of design drawings	●	●
Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
Demonstrate critical processes on a pilot production line	○	●
Test a production-representative prototype	○	○

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

GPS III Program

Technology, Design, and Production Maturity

The GPS III program currently reports all eight of its critical technologies are mature and the design is stable. In 2016, the program encountered technical issues involving capacitors—devices used to store energy and release it as electrical power. In investigating the capacitor failures, the program discovered the contractor skipped a key developmental step because a subcontractor had not conducted qualification testing for the capacitor's operational use in GPS III satellites. In response, the program conducted production lot reliability testing and design qualification testing of the capacitors. Design qualification successfully concluded in December 2016. However, test set-up problems invalidated the reliability testing of the production lot from which the failed capacitors originated. The program decided to assume risk and proceed “as is” with satellite 1, despite it being fitted mostly with capacitors from that lot. For satellites 2 and 3, the program ordered replacement of capacitors from the lot. The capacitor issue has also contributed to significant delays in the subcontractor’s delivery of navigation payload components, such as the mission data unit and transmitters. The program now projects a more than 6 month delay to the first satellite's “available for launch” date.

To prove out production processes prior to integrating and testing the first space vehicle, the program tested a system-level integrated prototype that includes all key subsystems and components but contains less built-in redundancy than the final configuration. Although the program previously reported a manufacturing process maturity level that indicated processes were in statistical control, the program has recently reported a lower level of maturity, indicating production processes are not yet fully in statistical control. While this reported maturity level is high enough to meet DOD's standards for production start, it does not meet the standard recommended by best practices.

Other Program Issues

Due to previously reported satellite launch availability delays, the program rebaselined its cost and schedule in January 2016. This rebaselining occurred prior to the February 2016 capacitor deficiencies, and, because of those and other subsequent technical issues, the contractor has now used up all available extra time in the program's schedule. The contractor is now projecting deliveries of satellites 1 through 8 will be delayed, on average, by about 6 months. The Defense Contract Management Agency is projecting an additional delivery delay of 9 months, on average, for each satellite beyond what the contractor now forecasts. According to contractor representatives, they are working with the navigation payload contractor to reduce the length of these delays.

Technical issues with both the GPS III satellite and the OCX Block 0 launch control and checkout system have combined to place the planned March 2018 launch date for the first GPS III satellite at risk. In order to launch in March 2018, the GPS III and OCX programs restructured their joint pre-launch integrated testing, reducing the campaign from 52 weeks to 42 weeks. Since then, a new 4 month delay to OCX readiness to begin launch preparation has forced additional campaign restructuring.

Because of extensive delays to OCX, the GPS III program is projecting to have delivered at least the first eight satellites and to have awarded a new contract for additional GPS III satellites before operational testing of the GPS III satellite with OCX Block 1 confirms the satellite's modernized signal capabilities.

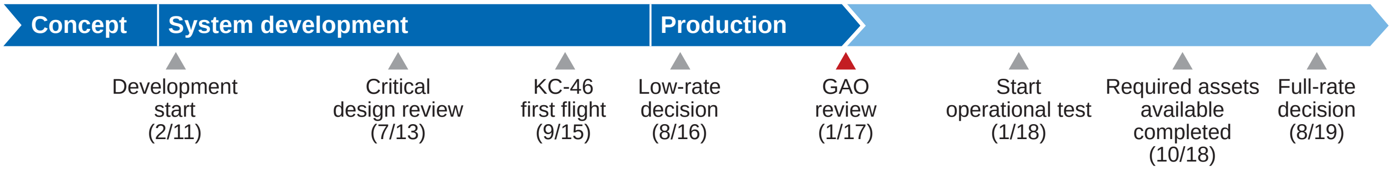
Program Office Comments

In commenting on a draft of this assessment, the program office noted the Air Force placed the first GPS III satellite into storage on February 27, 2017, after successfully completing all planned test and integration activities. The Air Force deferred declaring the first GPS III satellite available for launch due to a review of the Lockheed Martin A2100 propulsion sub-system. This review involved multiple space programs. The GPS program office is participating in the review and continues to monitor for any impacts to the planned GPS III initial launch capability in Spring 2018. The program office also provided technical comments, which were incorporated where deemed appropriate.

KC-46 Tanker Modernization Program (KC-46A)

The Air Force's KC-46 program plans to convert an aircraft designed for commercial use into an aerial refueling tanker for operations with Air Force, Navy, Marine Corps, and allied aircraft. The program is the first of three planned phases to replace the Air Force's aging aerial refueling tanker fleet. The KC-46 has been designed to improve on the KC-135's refueling capacity, efficiency, capabilities for cargo and aeromedical evacuation, and to integrate defensive systems.

Source: © 2016 Boeing Company - Photo by Paul Weatherman.



Program Essentials

Prime contractor: Boeing
Program office: Wright Patterson AFB, OH
Funding needed to complete:
R&D: $283.0 million
Procurement: $30,455.3 million
Total funding: $33,098.9 million
Procurement quantity: 156

Program Performance (fiscal year 2017 dollars in millions)

	As of 02/2011	Latest 06/2016	Percent change
Research and development cost	$7,432.2	$6,531.3	-12.1%
Procurement cost	$36,089,9	$34,266.5	-5.1%
Total program cost	$47,534.9	$43,626.5	-8.2%
Program unit cost	$265.558	$243.724	-8.2%
Total quantities	179	179	0.0%
Acquisition cycle time (months)	78	92	17.9%

In August 2016, the KC-46 program entered low-rate production with its three critical technologies fully mature. Although the Air Force considered the KC-46 design stable at the July 2013 critical design review, Boeing later discovered wiring issues that resulted in several changes to the aircraft's wiring system. The wiring design was finalized in March 2016 after Boeing had started producing aircraft. Boeing plans to correct the wiring on already produced aircraft prior to delivery to the Air Force. Under the terms of the development contract, Boeing bears the cost of correcting these deficiencies. According to Air Force and Boeing officials, Boeing will not make contractually-required deliveries at the required assets availability date in August 2017. Instead, Boeing plans to deliver the first 18 aircraft by February 2018, with the wing aerial refueling pods following in October 2018.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

KC-46A Program

Technology and Design Maturity

The KC-46's three critical technologies—two software modules related to situational awareness and a three-dimensional display that allows the crew to monitor aerial refueling activities—are fully mature. At its July 2013 critical design review (CDR), the program had released over 90 percent of its design drawings. However, following CDR, Boeing discovered aircraft wiring deficiencies that have required it to re-design the wiring system to resolve separation issues. After several modifications, Boeing finalized the wiring design in March 2016.

As of December 2016, Boeing had completed about half of the planned KC-46 developmental testing. Until this testing completes, Boeing may find additional technical issues that may require design changes. For example, during demonstration flights, Boeing found a technical issue with the refueling boom that delayed the production decision by 4 months.

Production Maturity

Boeing has manufactured four development aircraft and has begun producing the first 12 low-rate initial production aircraft. Boeing is correcting the wiring on already produced low-rate initial production aircraft by incorporating the final wiring design. Under the terms of the development contract, Boeing bears the cost of correcting these deficiencies. Program officials state they will continue to monitor and assess production maturity leading up to the full-rate production decision in 2019. The program intends to purchase more than 25 percent of its total aircraft during low-rate initial production. Generally, programs must provide a rationale if low-rate initial production quantities are going to exceed 10 percent of total quantities. The Under Secretary of Defense for Acquisition, Technology and Logistics approved this acquisition strategy for the KC-46 program to avoid a break in the production line.

Other Program Issues

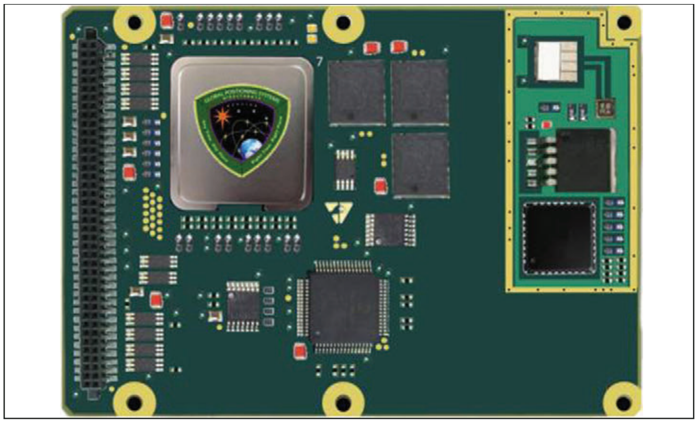
The Under Secretary of Defense for Acquisition, Technology and Logistics approved the KC-46 program to enter low-rate initial production in August 2016, one year later than originally planned. Boeing has proposed modifying its contract to delay delivery dates to account for testing and other delays it is currently experiencing, including qualifying the wing aerial refueling pod drogue systems, which are used to refuel two Navy or allied aircraft simultaneously. According to program officials, Boeing plans to deliver the first 18 aircraft with refueling booms and centerline drogue systems by February 2018. Wing aerial refueling pod components will be delivered in October 2018. At that point, Boeing will have delivered these items 14 months after their required availability in August 2017. Program officials are currently negotiating the necessary contract modifications related to this delay.

Program Office Comments

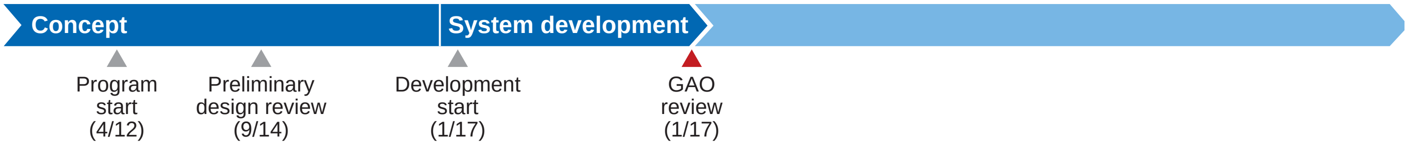
In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Military GPS User Equipment (MGUE) Increment 1

The Air Force's MGUE program plans to develop GPS receivers compatible with the military's next-generation GPS signal, Military-Code. The modernized receivers will provide U.S. forces with enhanced position, navigation, and time capabilities, while improving resistance to existing and emerging threats, such as jamming. The program consists of two increments. Increment 1, assessed here, leverages technologies from the Modernized User Equipment program to develop receivers for aviation, maritime, and ground platforms.



Source: U.S. Air Force.



Program Essentials

Prime contractors: L-3, Raytheon, Rockwell Collins International
Program office: El Segundo, CA
Funding needed to complete:
  R&D: $585.1 million
  Procurement: $0.0 million
  Total funding: $585.1 million
  Procurement quantity: 0

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 10/2016	Percent change
Research and development cost	NA	$1,143.5	NA
Procurement cost	NA	NA	NA
Total program cost	NA	$1,143.5	NA
Program unit cost	NA	NA	NA
Total quantities	NA	0	NA
Acquisition cycle time (months)	NA	NA	NA

MGUE entered system development in January 2017 with four of five critical technologies mature, but independent reviews raised concerns about past technology maturity assessments. MGUE recently began building finished hardware for testing and integration, but contractors will continue to incrementally develop and deliver software. Integration testing—during which time problems may be discovered—will not be completed until 2021, meaning the services are unlikely to have sufficient knowledge on which to base a procurement decision. The National Defense Authorization Act for Fiscal Year 2011 generally prohibits DOD from obligating or expending funds for GPS user equipment after fiscal year 2017 unless that equipment is capable of receiving military-code. The Secretary of Defense may waive this limitation under certain circumstances, or certain exceptions may apply.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

MGUE Increment 1 Program

Technology and Design Maturity

The MGUE Increment 1 program entered system development in January 2017 and has assessed four of its five critical technologies—military-code acquisition engine, military-code cryptography, selective availability anti-spoofing module functionality, and anti-tamper—as mature. Anti-spoof is nearing maturity. However, independent reviews questioned past assessments of the program's technology maturity. MGUE maturity levels were last formally assessed during a November 2014 independent technology readiness assessment. At that time, DOD's Director, Operational Test and Evaluation expressed concerns about one of the Air Force's test demonstrations and emphasized in a memorandum to the Under Secretary of Defense for Acquisition, Technology and Logistics the Air Force had overstated MGUE maturity, and the demonstration results were more mixed than the service indicated. In September 2015, the Air Force Operational Test and Evaluation Center initiated an operational assessment of MGUE, but then terminated the assessment before completing it due to immature test articles and the lack of developmental performance testing and data. A senior program official indicated the software immaturity in MGUE test articles was largely responsible for the poor performance during the operational assessment.

In 2016, the program began providing final test articles to ground, air, and maritime platform offices to support risk reduction and subsystem integration activities. These test articles are finished hardware components, but the software they contain is incomplete. The three MGUE contractors will develop and deliver additional software increments, which will be uploaded to the existing hardware to support further test activities, including integration testing with the services' lead platforms. MGUE is scheduled to complete this phase of testing, which commonly reveals problems, in 2021.

Other Program Issues

MGUE will not have a production decision and the program's acquisition strategy does not provide for equipment procurement beyond the final test articles. Once operational testing is complete, the military services will assume responsibility for developing MGUE technology to a production-ready status, as well as funding, procuring, and integrating the components on their platforms.

The National Defense Authorization Act for Fiscal Year 2011 generally prohibits DOD from obligating or expending funds for GPS user equipment after fiscal year 2017 unless that equipment is capable of receiving military-code signals. However, due to delays in the program's operational testing schedule, the military services are unlikely to have sufficient knowledge to begin MGUE procurement at the start of fiscal year 2018. The Secretary of Defense may waive this funding limitation under certain circumstances, or exceptions may apply. Officials from each military service indicated they are likely to request a waiver.

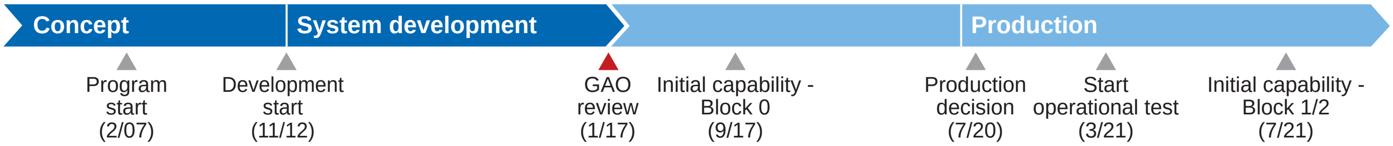
Program Office Comments

According to program officials, MGUE is conducting a test program intended to uncover risk as early as possible and verify the functional baseline, including testing on platforms and in software integration labs. Program officials report performance will be demonstrated through testing and will support the services need to procure MGUE receivers. Officials further noted program managers for non-lead platforms may make decisions on when to incorporate MGUE Increment 1 technology prior to the completion of the program.

Next Generation Operational Control System (GPS OCX)

The Air Force's GPS OCX is primarily a software development program to replace the existing ground control system. Intended to ensure reliable, secure delivery of position and timing information to military and civilian users, OCX software will be delivered in blocks, each providing upgrades as they become available. We assessed the first three blocks: Block 0 for initial, limited testing of new satellites; Block 1 for satellite control and basic military signals; and Block 2 for modernized military and additional navigation signals.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Raytheon
Program office: El Segundo, CA
Funding needed to complete:
R&D: $2,183.4 million
Procurement: $0.0 million
Total funding: $2,183.4 million
Procurement quantity: 1

Program Performance (fiscal year 2017 dollars in millions)

	As of 11/2012	Latest 09/2016	Percent change
Research and development cost	$3,591.8	$5,498.4	53.1%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$3,591.8	$5,498.4	53.1%
Program unit cost	$3,591.802	$5,498.444	53.1%
Total quantities	1	1	0.0%
Acquisition cycle time (months)	55	116	110.9%

The GPS OCX program considers all of its 14 critical technologies mature. The program awarded a development contract in early 2010 and entered system development in late 2012. The next year, the Air Force paused OCX development to address problems it believed were causing significant cost and schedule growth, and acknowledged program and contractor understanding of key requirements, especially cybersecurity, was deficient. The Air Force resumed OCX development in 2015, but the program continued to experience cost and schedule growth. Last year, the Air Force determined OCX would breach a statutory critical unit cost growth threshold, and require recertification to continue development. DOD recertified the program in October 2016, with cost growth of over 50 percent from the original program baseline and a 24-month schedule extension.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

GPS OCX Program

Technology and Design Maturity

The OCX program currently assesses its 14 critical technologies as mature. The OCX program does not track the metrics we use to measure design maturity, such as the number of releasable design drawings, as it is primarily a software development effort.

OCX entered system development in November 2012 with all 14 critical technologies nearing maturity. This milestone was preceded by development contract award in February 2010 and preliminary design review in August 2011. In 2013, following high cost and schedule growth, the Air Force paused OCX development to identify and address the root causes thereof. According to program officials, the Air Force and the contractor had poorly understood key requirements, particularly for cybersecurity, which led to difficulty in developing effective software. Specifically, OCX contractor representatives said they did not fully understand the cybersecurity implementation requirements designed to help ensure system resistance to, and operation during, cyber-attacks.

In 2015, the Air Force restarted OCX software development activities prior to fully identifying and addressing root causes and without realistic cost and schedule estimates. DOD recently conducted a new root cause analysis, which identified that (1) external factors drove the program to an unrealistic schedule, (2) costs to fully implement information assurance requirements were underestimated, and (3) both the contractor and government had performed poorly. In December 2015, 2 months after re-baselining the schedule, the Office of the Under Secretary of Defense for Acquisitions, Technology and Logistics directed a high-risk, 24-month schedule extension to Block 1. OCX is also scheduled to repeat the milestone review associated with entry into system development by June 2017, after the contractor develops new cost and schedule baselines.

Other Program Issues

The program remains at high-risk of cost growth, schedule delays, and performance shortfalls to the deliveries of Block 0 and Block 1. The revised schedule optimistically assumes higher levels of software coding productivity than the contractor has previously accomplished, and reductions in defect rates using an entirely new software development methodology. Further, the schedule has insufficient margin for unexpected issues. In addition, although the contractor has nearly doubled the software engineers working on OCX, it is having difficulty training those staff on software development.

Delivery of OCX Block 0 may affect the program created to offset OCX delays, known as the Contingency Operations (COps) program. The COps program is intended to modify the existing GPS ground control system to allow it to control GPS III satellites after launch. The OCX Block 0 contractor delivery has slipped to September 2017, requiring some replanning with COps to prevent disrupting testing plans for common test equipment.

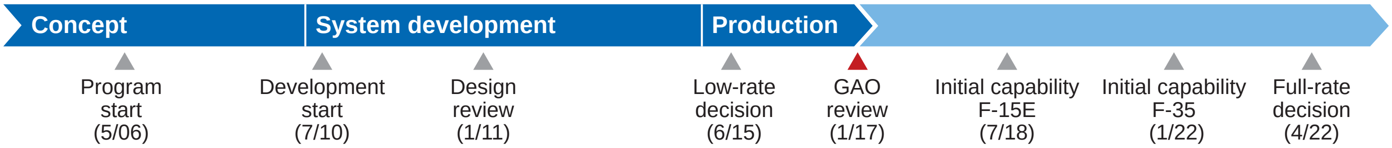
Program Office Comments

In commenting on a draft of this assessment, program officials provided the following information. Block 0 acceptance is on track for September 2017. The Air Force was directed at the December 2015 Deep Dive program review to plan to have the Block 1 software ready to transition to operations by July 2021. This date is being reassessed as part of the program’s breach of a statutory critical unit cost growth threshold and subsequent program re-baselining planned for the summer 2017. All remaining Block 2 scope has been rephased to deliver concurrently with Block 1, so there is no longer a separate Block 2 delivery for OCX. Technical comments were also provided by the program office, which were incorporated where deemed appropriate.

Small Diameter Bomb Increment II (SDB II)

The Air Force's Small Diameter Bomb Increment II (SDB II) is designed to provide attack capability against mobile targets in adverse weather from extended range. It combines radar, infrared, and semiactive laser sensors in a tri-mode seeker to acquire, track, and engage targets. It uses airborne and ground data links to update target locations, as well as GPS and an inertial navigation system to ensure accuracy. SDB II will be integrated with F-15E, F/A-18E/F, and F-35 aircraft, among others.

Source: © 2009 Raytheon Company.



Program Essentials

Prime contractor: Raytheon
Program office: Eglin AFB, FL
Funding needed to complete:
- R&D: $497.2 million
- Procurement: $2,349.3 million
- Total funding: $2,846.5 million
- Procurement quantity: 16,606

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2010	Latest 08/2016	Percent change
Research and development cost	$1,784.1	$1,832.2	2.7%
Procurement cost	$3,316.2	$2,454.6	-26.0%
Total program cost	$5,100.3	$4,286.8	-15.9%
Program unit cost	$0.297	$0.250	-15.9%
Total quantities	17,163	17,163	0.0%
Acquisition cycle time (months)	72	96	33.3%

SDB II entered production in June 2015 with all of its critical technologies mature; however, its design was unstable. The program still has significant testing to complete, and any problems discovered could result in further design changes. Since January 2016, the program has conducted 25 flight tests and failed 6 of them. These flight test failures occurred during all three of SDB II's attack modes. The program successfully retested two of the failed tests and plans to retest others. These failures have contributed to the program's 6-month delay in initial operational capability with the F-15E. The program also successfully completed the corrosive atmosphere testing that was required before awarding a second production contract in September 2016. The program's critical processes for production are in statistical control.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	●	●
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

SDB II Program

Technology and Design Maturity

SDB II's four critical technologies—guidance and control, multi-mode seeker, net ready data link, and payload—are mature. These technologies did not mature though until almost 5 years after development start, in time for the program's low-rate production decision in June 2015.

Deficiencies in SDB II's design were revealed at production start as a result of qualification and flight test failures that required hardware and software changes. Additional changes and retrofits remain possible as SDB II continues developmental testing. Since January 2016, the program has conducted 25 flight tests in all three of the SDB II attack modes. Six of these tests did not achieve their objectives. Specifically, one live fire test, one government confidence test, and 2 guided flight tests failed to impact their intended targets; one laser flight test performed as intended, but the pilot lost the track of the intended target and the weapon missed; and one coordinate attack flight test detonated 10 times above the planned detonation height. The program successfully retested the 2 guided flight tests and plans to retest both the laser flight test and the coordinate attack flight test. According to officials, the program has modified SDB II software and hardware to correct for known failures.

These testing outcomes contributed to a 6-month delay in SDB II's initial operational capability with the F-15E. The program began a "government confidence test" program in October 2016 and has conducted 6 of the 28 shots, all of which will occur in the normal attack mode. The program added these tests at the direction of the Office of the Secretary of Defense to test against additional, real world scenarios. The program plans to complete this test program within 9 months. However, failures of any of the government confidence tests could delay subsequent tests.

Production Maturity

The contractor is scheduled to begin low-rate initial production of the first 144 units (Lot 1) in March 2017, following current production of SDB II test assets. The program awarded a second production contract (Lot 2) in September 2016 for 250 additional units and a third production contract (Lot 3) in January 2017 for 312 additional units. According to the program, its critical manufacturing processes are in statistical control.

Other Program Issues

In 2016, the program completed corrosive atmosphere environmental testing of SDB II, which revealed deficiencies. This testing built upon prior testing in 2014 and 2015, which informed SDB II's low-rate production decision in June 2015. According to officials, this testing simulated the bomb's exposure to various environmental conditions for an extended period outside of its protective container. In the 2016 testing, SDB II passed the required software tests but failed functionality tests. Specifically, the dome cover, wings, air turbine alternator, and UHF antenna failed to deploy. The program implemented corrective fixes and then retested successfully. According to the program, this successful test was necessary before the program could award the Lot 2 production contract. Officials stated the design changes from the environmental test will be incorporated into Lot 2 production, which will cause Lot 1 and 2 configurations to be slightly different. According to officials, recent environmental testing was mainly to ensure SDB II survivability after exposure to the environment of Navy ships, although the Navy does not intend to procure any bombs until Lot 4 production.

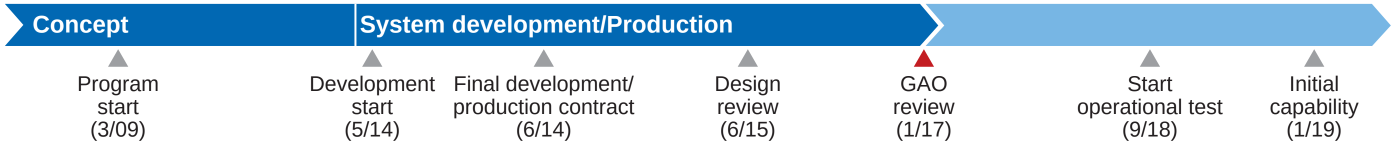
Program Office Comments

According to program officials, SDB II is demonstrating effectiveness and lethality in flight test. The program is events-based and is effectively resolving technical issues. Recent flight tests demonstrated successful performance against two important requirements: performance in adverse weather and weapon control by a third party.

Space Fence Ground-Based Radar System Increment 1

The Air Force's Space Fence Increment 1 program is developing a large, ground-based radar to detect and track objects in low and medium Earth orbit and provide this information to a space surveillance network. Space Fence is designed to use high radio frequencies to detect and track more and smaller objects than previous systems. The Air Force awarded a development and production contract for the first site in June 2014, and included a second site as an option, which, if exercised, will be acquired as Increment 2 in a separate program.

Source: U.S. Air Force.



Program Essentials

Prime contractor: Lockheed Martin
Program office: Hanscom AFB, MA
Funding needed to complete:
R&D: $219.9 million
Procurement: $0.0 million
Total funding: $219.9 million
Procurement quantity: 0

Program Performance (fiscal year 2017 dollars in millions)

	As of 06/2014	Latest 08/2016	Percent change
Research and development cost	$1,632.1	$1,553.3	-4.8%
Procurement cost	$0.0	$0.0	0.0%
Total program cost	$1,632.1	$1,553.3	-4.8%
Program unit cost	$1,632.122	$1,553.276	-4.8%
Total quantities	1	1	0.0%
Acquisition cycle time (months)	124	118	-4.8%

Since our last assessment, the Space Fence program began testing an integrated prototype radar that includes production-representative elements and uses software developed for the operational radar. According to the Air Force, the prototype has demonstrated up to 70 percent of the operational radar's capability. The program recently delayed its operational testing and initial capability dates due to challenges with construction of the facilities to house the radar. However, program officials report these delays will not affect the program's ability to meet its schedule requirements. To accommodate the projected volume of data generated by Space Fence, the Air Force is developing a new data processing system under a separate program. Despite recent delays in this program, the Air Force expects to developmentally test the data processing system with Space Fence in 2018.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

Space Fence Inc 1 Program

Technology Maturity

A February 2015 technology readiness assessment showed all seven of the program's critical technologies are fully mature. This maturity was achieved by integrating the technologies into a prototype radar array—and demonstrating that array in an operational environment—in support of the critical design review. Space Fence technologies provide capabilities for transmitting and receiving radar signals from the radar array.

Design and Production Maturity

In early 2016, the program began testing a prototype that uses production-representative hardware and runs the software designed for the operational radar. According to the program, the prototype has demonstrated about 70 percent of Space Fence performance requirements. According to the program office, the prototype is not a contract requirement; the contractor elected to build it as part of the development process and it has helped them learn more about the installation of radar components and to identify and correct software defects.

The Space Fence program is tracking the maturity of two critical manufacturing processes for components of the radar's transmit and receive modules. The contractor has not demonstrated these processes to be in statistical control, as recommended by best practices, but has achieved the level of maturity required in the system development contract. According to the program office, it is tracking a manufacturing delay for one component of the radar but expects to complete production and ship the components within the necessary timeline.

Other Program Issues

The Space Fence program delayed its operational testing and initial operational capability events due to challenges constructing facilities to house the radar and poor performance by a subcontractor. These delays eliminated the extra time built into the contractor's schedule, but program officials stated the program remains on track to meet its baseline schedule requirements.

Space Fence Increment 1 is expected to meet the Air Force's requirements for initial operational capability, but full capability will only be achieved once a second site is operational. Development and production of the second site, which will represent an Increment 2 program, is a contract option. The program noted the Air Force will need to make a preliminary decision on an Increment 2 by summer 2017 for budgeting purposes, though the option for a second site will not be exercised until Increment 1 achieves initial operational capability.

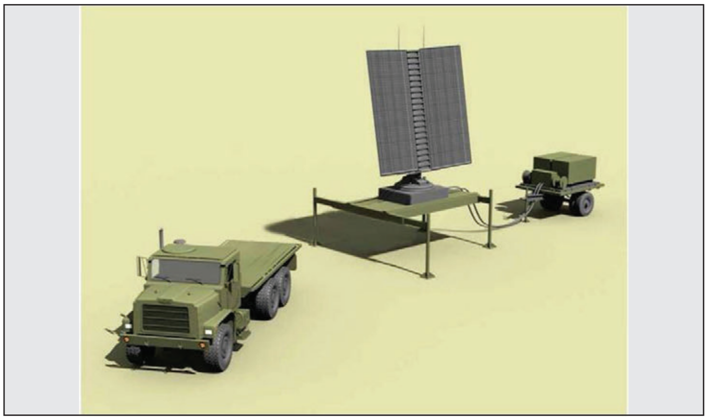
The Joint Space Operations Center (JSpOC) at Vandenberg AFB is acquiring new data processing capabilities under its JSpOC Mission System (JMS), designed in part to enable processing of the increased volume of data expected from Space Fence. However, the JMS program has experienced delays over the past year. Completion of developmental testing of JMS software has been delayed from August 2015 to February 2018. According to the Space Fence program office, this software is needed to complete Space Fence testing in September 2018, and the JMS schedule currently supports this date. Alternatively, if JMS software is further delayed, Space Fence developmental testing could be accomplished through modeling and simulating JMS capabilities, according to the Space Fence program. However if this option were used for operational testing, it may cause schedule delays as it would require accreditation of the model—an activity for which the Air Force has not budgeted or planned.

Program Office Comments

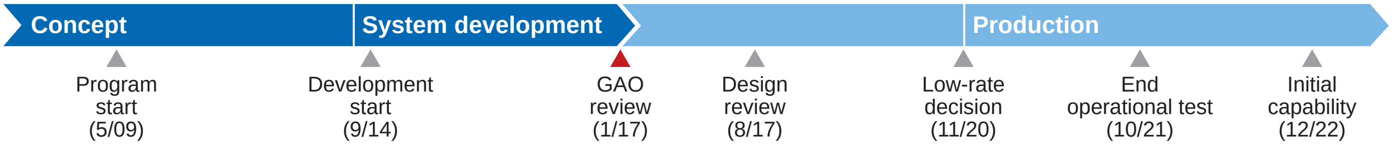
In commenting on a draft of this assessment, the program office noted the program continues to move forward with minimal impacts to cost and schedule since contract award. It concluded software development in October 2016 and anticipated completing 85 percent of radar manufacturing by the end of 2016. The program stated the construction of the sensor site and power plant annex facilities on Kwajalein was an issue early in 2016, and the contractor took steps to offload work from an underperforming second tier subcontractor, including replacing the construction subcontractor team lead and bringing in its own senior construction managers. In December 2016, the program successfully verified 94 percent of the 298 requirements tested by the contractor. In 2017, the program will focus on completing facility construction, radar installation and check out, integrating the sensor site with the power plant annex, and providing power to the transmit and receive arrays.

Three-Dimensional Expeditionary Long-Range Radar (3DELRR)

The Air Force's 3DELRR is being developed as a long-range, ground-based sensor for detecting, identifying, tracking, and reporting aerial targets, including highly maneuverable and low observable targets. The system intends to provide real-time data and support a range of operations in all types of weather and terrain. It will replace the Air Force's AN/TPS-75 radar system, which has reached the end of its service life and is becoming more costly to maintain.



Source: U.S. Air Force.



Program Essentials

Prime contractor: TBD
Program office: Hanscom AFB, MA
Funding needed: (FY 2017 to FY 2021):
R&D: $150.7 million
Procurement: $267.5 million
Total funding: $418.2 million
Procurement quantity: 11

Program Performance (fiscal year 2017 dollars in millions)

	As of	Latest 11/2016	Percent change
Research and development cost	NA	$483.8	NA
Procurement cost	NA	$938.5	NA
Total program cost	NA	$1,422.2	NA
Program unit cost	NA	$40.636	NA
Total quantities	NA	35	NA
Acquisition cycle time (months)	NA	163	NA

In October 2014, 3DELRR entered system development and awarded a development contract. At this point, all of the program's critical technologies were nearing maturity. However, bid protests delayed the start of development work, and the Air Force re-opened the competition in response to issues raised in the protests. The Air Force plans to award a new development contract in the second quarter of fiscal year 2017, more than 2 years after the original contract award. Prior to the start of development, the program took steps to reduce technical risk and costs by conducting system-level competitive prototyping and analyzing the tradeoffs between costs and requirements. The program's remaining risks may vary based on the design selected for development, although software integration will be a risk regardless of the contractor.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	○
• Complete a system-level preliminary design review	●	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	▨	▨
• Test a system-level integrated prototype	▨	▨
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	▨	▨
• Demonstrate critical processes on a pilot production line	▨	▨
• Test a production-representative prototype	▨	▨

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

3DELRR Program

Technology and Design Maturity

The 3DELRR program entered system development in October 2014 with all of its critical technologies approaching maturity. Shortly thereafter, the Air Force suspended performance on the development contract awarded to Raytheon as a result of bid protests by Lockheed Martin and Northrop Grumman. In January 2015, GAO dismissed the protests when the Air Force agreed to take corrective actions to address the issues raised. The program subsequently re-entered the source selection phase, which it expects to conclude in early 2017.

Following the new source selection, the program plans to fully mature its critical technologies by demonstrating them in a realistic environment. According to program officials, the critical technologies will vary based on the contractor design selected for development. Further, as a result of the ongoing source selection process, the program office was not yet able to provide us with data on 3DELRR design drawings, which we use to evaluate design stability under our best practices criteria. The program office did, however, identify several developmental risks it is tracking that could carry design implications. For example, 3DELRR's planned design is software-intensive, and program officials identified software development as a risk because, if not performed adequately, subsequent integration of hardware and software could be delayed. Program officials also stated integrating the extensive amount of re-used software code contributed to the level of risk, but noted each contractor is planning to test software prior to integration with the system. In addition, 3DELRR is expected to use a new semiconductor technology, which relies on gallium nitride-based modules for individual radiating elements key to transmitting and receiving electromagnetic signals, rather than the legacy gallium arsenide transmit/receive modules. While the long-term reliability and performance of gallium nitride is unknown and could affect radar sensitivity and power requirements, it has the potential to provide higher efficiency with lower power and cooling demands than legacy semiconductor technology.

To reduce technical risk ahead of system development, the 3DELRR program conducted system-level competitive prototyping, held preliminary design reviews with multiple contractors, and conducted capability demonstrations. According to program officials, these efforts helped the program develop critical technologies, refine technical requirements and cost estimates, and assess manufacturing readiness.

Other Program Issues

Program officials stated the program re-entered source selection in May 2015 and had originally planned to award a new system development contract in the second quarter of fiscal year 2016. However, program officials stated the contract award has been delayed a year to the second quarter of fiscal year 2017, in part because the program added a full-rate production option to the solicitation in July 2016. The original development contract awarded in October 2014 included a low-rate initial production option, and the Air Force had planned to award a separate sole source contract for full-rate production. Program officials stated the full-rate production option was added to take advantage of the increased competition resulting from 3DELRR's participation in the Defense Exportability Features Program, which provides contractors an early opportunity to engage in DOD-sponsored foreign military sales and associated logistics support.

Program Office Comments

The program office concurred with this assessment and provided technical comments, which were incorporated where appropriate.

Common Name: APT

Advanced Pilot Trainer (APT)

With its Advanced Pilot Training program (APT), the Air Force is replacing its legacy T-38C trainer fleet and related ground equipment by developing and fielding newer, more technologically advanced trainer aircraft and an associated ground based training system. The APT will meet the Air Force's advanced fighter pilot training needs and close training gaps, which the T-38C cannot fully address.

Source: U.S. Air Force

Current Status

In October 2009, the Air Force identified a gap in its aircraft training capabilities beginning in 2018. In May 2010, the Under Secretary of Defense for Acquisition, Technology and Logistics approved the Air Force's plans to conduct an analysis of alternatives for closing this gap. In June 2011, the analysis of alternatives recommended that the existing training aircraft, the T-38C, be replaced because a modification program would not be cost effective, nor address all capability gaps, and would leave the Air Force with aging T-38C airframes.

The Air Force released a request for proposals for APT in December 2016 and plans to award a fixed-price development and early production contract for by December 2017. According to the program office, all required technology planned for the aircraft is mature. As a result, the OSD approved Acquisition Strategy initiates the program at Milestone B, beginning with an Engineering and Manufacturing Development (EMD) phase limited to 4 years. The Air Force plans to begin development on the APT program in December 2017 before a preliminary design review is held, which would require a waiver from statutory requirements, and without conducting competitive prototyping—actions that are inconsistent with best practices for product development. However, according to Air Force officials, all perspective vendors will offer systems which are well beyond the prototype phase. The officials also maintain APT's technical risks are low because vendors must provide flight-test data from aircraft that closely match the offered aircraft. Because the APT program does not yet have an approved acquisition program baseline, the estimated development cost shown below was obtained from the Air Force's fiscal year 2017 budget submission. The Air Force expects APT to achieve initial operational capability in the fourth quarter of fiscal year 2024.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):

Total program: TBD

Research and development (fiscal years 2015 through 2021): $836.7 million

Procurement: TBD

Quantity: 350

Next Major Program Event: Milestone B decision planned for first quarter fiscal year 2018

Program Office Comments: According to Air Force officials, the APT acquisition strategy pursues capabilities and design solutions that already exist in the marketplace. Competitive offerings will be well beyond prototype and preliminary designs, and in some cases offering systems that are currently in production.

Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)

With its JSTARS Recap program, the Air Force is replacing aging JSTARS aircraft—manned Battle Management Command and Control (BMC2) systems that provide surveillance and information on moving and stationary ground targets—while seeking to reduce weapon system operating and sustainment costs, replacing and improving JSTARS capability, and minimizing development and integration costs.

Source: U.S. Air Force

Current Status

The Air Force's acquisition strategy for JSTARS Recap is to competitively procure in-production, business class jets and equip them with modern search radar, BMC2, and broad-spectrum communication subsystems. To reduce technical and integration risks, as well as future upgrade costs, the program office plans to integrate currently available systems and mature technologies using open system architecture and open mission systems, in accordance with the design architecture developed by the program office.

In December 2015, the program entered the technology maturation and risk reduction phase. The program awarded three firm-fixed-price contracts to Lockheed Martin, Northrop Grumman, and Boeing for limited development work ahead of the program's engineering and manufacturing development (EMD) phase. Each contractor developed a preliminary design and demonstrated major subsystem prototypes. Program officials stated the preliminary design reviews resulted in three viable designs. Also according to program officials, within the technology maturation and risk reduction phase, the program is conducting radar risk reduction efforts with Northrop Grumman and Raytheon to mature radar subsystem technologies, demonstrate prototypes, further reduce integration risk, and foster competition.

The program identified seven candidate critical technologies and is currently conducting an independent technology readiness assessment (TRA) before EMD. The program expects to complete the TRA by June 2017 and has preliminarily assessed almost all candidate critical technologies as at least nearing maturity. The Air Force expects JSTARS Recap to achieve initial operational capability in the fourth quarter of fiscal year 2024.

Estimated Total Program Cost (fiscal year 2017 dollars):
Total program: $7,126.1 million
Research and Development: $3,039.8 million
Procurement: $4,086.3 million
Total Quantity: 17

Next Major Program Event: Engineering and Manufacturing Development start, Fiscal Year 2018

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Common Name: PAR

Presidential Aircraft Recapitalization (PAR)

The PAR program plans to replace the current VC-25A presidential aircraft with a new modified commercial plane to transport the President of the United States. The PAR aircraft will be a four engine wide-body, commercial derivative aircraft, uniquely modified to provide the President, staff, and guests with safe and reliable air transportation with the same level of security and communications capability available in the White House.

U.S. AIR FORCE

Source: U.S. Air Force.

Current Status

DOD approved the PAR program's acquisition strategy in September 2015 after several years of acquisition planning and studies to reduce program execution risk. In September 2016, the Under Secretary of Defense for Acquisition, Technology and Logistics (USD AT&L) approved the program for initiation as a Major Defense Acquisition Program at the Engineering and Manufacturing Development (EMD) phase and authorized the release of a Request for Proposal to cover efforts in the EMD phase, which will result in modification and testing of two commerical aircraft to be fielded to meet presidential airlift requirements. Prior to entering EMD, USD AT&L approved waiving several requirements related to affordability, funding, technology maturity, and preliminary design review. USD AT&L determined that without such waivers, DOD would be unable to meet critical national security objectives—specifically, completing these requirements would significantly delay the acquisition of the new aircraft and replacement of the legacy aircraft.

The PAR program continues design and risk reduction studies, which may assist the Air Force in making additional trade-offs among cost, schedule and performance objectives prior to establishing the Acquisition Program Baseline and determining final aircraft quantities in 2017. The program plans to modify and test the new 747-8 aircraft in a phased approach starting in 2019, using research and development funding. Program officials acknowledge technology integration risks but stated the majority of the required mission-related systems are currently operating on different weapon systems and have legacy or related equivalents onboard the existing presidential aircraft. Once development is complete, the aircraft will be delivered as fully capable to support presidential missions, planned for fiscal year 2024.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program (fiscal years 2010-2021): $3,074.0 million
Research and development (fiscal years 2010-2021): $2,759.9 million
Procurement: N/A
Military construction (fiscal years 2017-2019): $314.1 million
Quantity: 2

Next Major Program Event: Start of preliminary design activities, second quarter fiscal year 2017

Program Office Comments: In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Common Name: WSF-M

Weather System Follow-on – Microwave (WSF-M)

The Air Force's WSF-M is expected to be DOD's next weather satellite system. WSF-M is intended to contribute to a family of space-based environmental monitoring systems that support military operations through remote sensing of weather conditions, such as wind speed and direction at the ocean's surface and space weather, and by providing real-time data to be used in models for weapon system planning and weather forecasting.

Source: U.S. Air Force.

Current Status

WSF-M is DOD's third effort to replace the aging Defense Meteorological Satellite Program, following two prior cancellations. The Air Force is developing WSF-M to satisfy 3 of 11 requirements that DOD examined in an analysis of alternatives and determined were mission critical, yet insufficiently met by other sources. WSF-M is to have two payloads—a microwave imager to collect data primarily on ocean surface vector wind and tropical cyclone intensity, and an energetic charged particle sensor to collect space weather data—on a polar-orbiting satellite.

As a precursor to WSF-M, an Operationally Responsive Space technology demonstration program is to use an existing microwave sensor from NASA's Jet Propulsion Laboratory. Combined with a new application of existing data, the demonstration is planned to partially meet ocean surface vector wind and tropical cyclone intensity requirements, supplement current operational capability, and inform WSF-M technology development. With WSF-M, the Air Force plans to fully meet all 3 requirements through a competitive award for up to two satellites and by hosting an energetic charged particle sensor. The Air Force approved the WSF-M acquisition strategy in October 2016. The technology demonstration is expected to be ready for launch in November 2017; the first WSF-M launch is expected in the middle of fiscal year 2023. Both are to be integrated into existing ground systems.

According to Air Force plans, WSF-M is expected to enter development with one critical technology. This critical technology, the polarimetric receiver, is expected to be mature by development start. According to the Air Force, other technologies are no longer considered critical. The Air Force has identified software development as a low to medium risk area.

Estimated Program Cost and Quantity (fiscal year 2017 dollars):
Total program: TBD
Research and development (fiscal years 2012 through 2022): $786.3 million
Procurement: TBD
Quantity: 1 (technology demonstration), 2 (development) (includes satellite quantities only)

Next Major Program Event: System preliminary design review, second quarter 2018

Program Office Comment: In commenting on a draft of this assessment, the Air Force provided technical comments, which were incorporated where deemed appropriate.

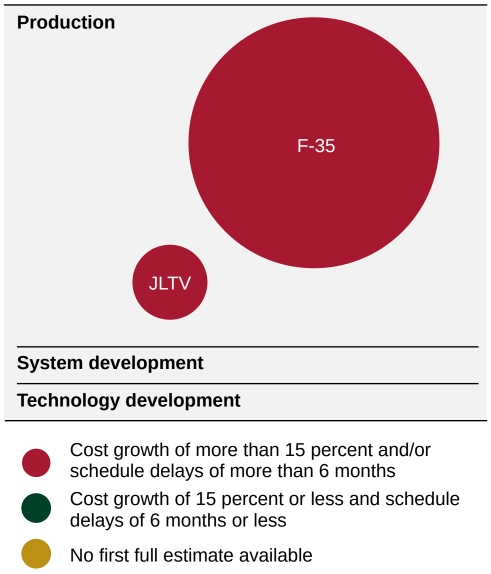
Joint DOD-wide Programs Summary

We completed individual assessments on two of the four “joint” or DOD-wide current and future major defense acquisition programs—the F-35 Lighting II and Joint Light Tactical Vehicle (JLTV) programs. We found DOD currently estimates a need of more than $233 billion in funding to complete the acquisition of these two programs. We also compared these two programs’ first full estimates of cost and schedule with their current estimates and found:

- net cost growth exceeds $100 billion, all of which occurred more than 5 years ago and is attributable to the F-35 Lightning II program, and
- program schedule delays average approximately 40 months.

Further, the F-35 program completed all the activities associated with the applicable knowledge based best practices we assess, although they were not fully complete at the time the knowledge points were reached.

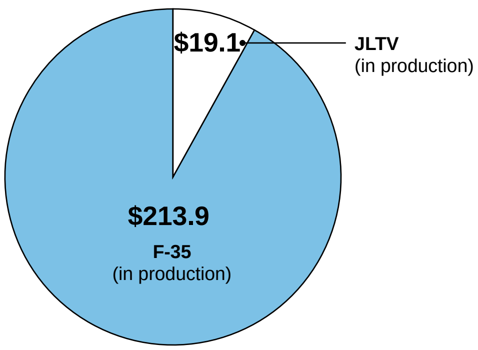
Acquisition Phase and Size of the Two Programs Assessed



Note: Bubble size is based on each program’s currently estimated future funding needed.

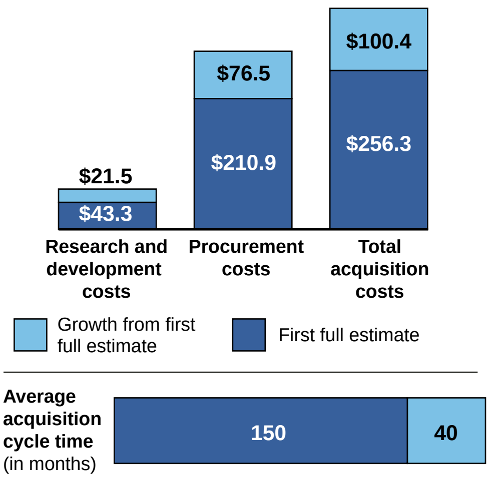
Currently Estimated Acquisition Cost for the Two Programs Assessed

Fiscal year 2017 dollars in billions



Cost and Schedule Growth on Two Programs in the Current Portfolio

Fiscal year 2017 dollars in billions



Note: In addition to research and development and procurement costs, total acquisition cost includes acquisition related operation and maintenance and system-specific military construction costs.

Summary of Knowledge Attained to Date for Programs Beyond System Development Start

	Knowledge Point (KP) 1 Resources and requirements match		**Knowledge Point 2** Product design is stable		**Knowledge Point 3** Manufacturing processes are mature	
Program common name	At KP1	Current Status	At KP2	Current Status	At KP3	Current Status
F-35 JSF	○	●	○	●	○	●
JLTV	○	●	○	- - -	○	○

● All applicable knowledge practices completed

○ One or more applicable knowledge practices were not completed

▨ Knowledge practice is not applicable

- - - Information not available for knowledge practice

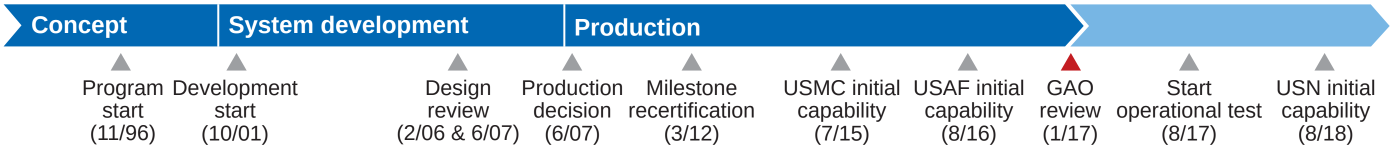
Source: GAO analysis of DOD data. | GAO-17-333SP

Joint DOD-wide Program Assessments

F-35 Lightning II Program (F-35)

DOD is developing and fielding a family of next generation strike fighter aircraft, integrating stealth technologies with advanced sensors and computer networking capabilities for the United States Air Force, Marine Corps, and Navy as well as eight international partners. The Air Force's F-35A is expected to replace the air-to-ground attack capabilities of the F-16 and A-10 and complement the F-22A. The F-35B variant is expected to replace the Marine Corps' F/A-18 and AV-8B aircraft. The F-35C will complement the Navy's F/A-18E/F.

Source: © 2016 Lockheed Martin.



Program Essentials

Prime contractors: Lockheed Martin, Pratt & Whitney
Program office: Arlington, VA
Funding needed to complete:
R&D: $1,706.7 million
Procurement: $209,658.2 million
Total funding: $213,918.1 million
Procurement quantity: 2,158

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2001	Latest 12/2015	Percent change
Research and development cost	$42,277.5	$63,838.6	51.0%
Procurement cost	$187,565.4	$267,912.7	42.8%
Total program cost	231,806.3	$336,152.4	45.0%
Program unit cost	$80.881	$136.814	69.2%
Total quantities	2,866	2,457	-14.3%
Acquisition cycle time (months)	175	237	35.4%

All of the F-35 program's critical technologies are fully mature. A previous critical technology that had not been fully matured has now been deferred to follow-on development. Although the aircraft designs were not stable at their critical design reviews in 2006 and 2007, all baseline engineering drawings have since been released. While developmental testing is progressing, design changes are likely until the program completes these tests. Manufacturing efficiency is steady, and program officials stated that critical production processes are in control. The program is planning follow-on modernization to address capability deferrals, upgrade existing capabilities, and integrate additional weapons into the F-35 aircraft.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	○	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	○	●
Product design is stable	DESIGN REVIEW	
• Release at least 90 percent of design drawings	○	●
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	●
• Demonstrate critical processes on a pilot production line	○	●
• Test a production-representative prototype	○	●

● Knowledge attained
▪▪▪▪ Information not available
○ Knowledge not attained
▨ Not applicable

F-35 Program

Technology and Design Maturity

All of the F-35 program's critical technologies are fully mature. In 2013, the program deferred plans for integrating a prognostics and health management system technology into the aircraft design. The program had identified this technology, which is part of the F-35 Autonomic Logistics Information System (ALIS), as critical but not fully mature. The program now plans to integrate this technology into the F-35 design as part of a later block of aircraft. In addition, the program has yet to incorporate engine health data into ALIS. Further, the program continues to address issues with other technologies including the next-generation helmet, which is currently providing degraded night vision capabilities at sea.

Although the aircraft designs were not stable at their critical design reviews in 2006 and 2007, the program has since released all baseline engineering drawings. As the program nears the end of developmental testing, officials continue to identify and address technical risks. For example, the prime contractor implemented design changes to address deficiencies with the arresting hook and engine and, during 2016, began addressing ejection seat problems. In addition, the Navy recently identified problems affecting the F-35C wing structure when carrying an AIM-9X missile and is identifying design changes. The program faces the risk of further design changes until developmental testing is complete.

Production Maturity

Aircraft manufacturing deliveries remain steady and totaled 199 production aircraft as of December 2016. Since the start of production, the contractor's production processes have continued to mature, and program officials stated that critical production processes are now in control. To enable continued improvements and to increase quality, the contractor tracks process control data and other quality indicators. Production part shortages remain a risk as suppliers face additional pressures of balancing an increased production rate amid the simultaneous need to sustain a growing operational fleet.

Other Program Issues

In July 2015, the Marine Corps declared F-35B initial operational capability (IOC) prior to meeting all expected requirements. In particular, F-35B offered only limited capabilities with respect to eight performance requirements, including those centered on sensor fusion, electronic warfare, and communication. The full capabilities for these requirements were delivered in a subsequent software upgrade. The Air Force declared F-35A IOC in August 2016 having met and delivered all expected capabilities. The Navy F-35C IOC date is scheduled for August 2018.

F-35 flight testing has been consistently delayed over the past several years, and in the past year, the program encountered additional delays. The program estimates it needs an additional 5 months to complete developmental testing and $451 million to complete the development program. These estimates are optimistic and assume that the program will be able to accomplish remaining tests at a significantly faster pace than historically demonstrated. The Director, Operational Test and Evaluation reported that the program will need significantly more time and money than it now forecasts, which could jeopardize the program's schedule for initial operational test and evaluation, full-rate production, and follow-on modernization.

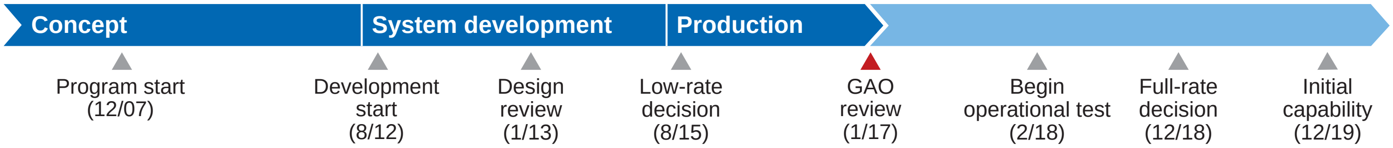
Program Office Comments

According to program officials, the prognostics and health management system, less the downlink capability, has been operating on the aircraft and continues to mature. The prognostics and health management system downlink capability was deferred due to certification concerns, not immature technology. Currently, officials state engine maintenance data is processed using a dedicated engine tool. Engine data will be processed in ALIS with the fielding of ALIS 2.0.2 in spring 2017, and the update will eliminate the need for the engine tool workaround. Officials also said the night vision capability of the helmet has been significantly improved with the newest generation helmet. F-35s are now permanently operating overseas. In January 2017, the Marine Corps deployed 10 F-35Bs from its air station in Yuma, Arizona to the air station in Iwakuni, Japan. Program officials noted some risk exists to completion of system development; however, steady reduction of known challenges and a slowly decreasing rate of new discovery should allow for completion within the established acquisition program baseline.

Joint Light Tactical Vehicle (JLTV)

The Army and Marine Corps' JLTV is a family of vehicles being developed to replace the High Mobility Multipurpose Wheeled Vehicle (HMMWV) for some missions. The JLTV is expected to provide protection for passengers against current and future battlefield threats, increased payload capacity, and improved automotive performance over the up-armored HMMWV. It will also be transportable by air and ship. Two- and four-seat variants are planned with multiple mission configurations.

Source: U.S. Army.



Program Essentials

Prime contractor: Oshkosh Defense LLC
Program office: Harrison Township, MI
Funding needed to complete:
  R&D: $122.0 million
  Procurement: $19,010.8 million
  Total funding: $19,132.8 million
  Procurement quantity: 53,372

Program Performance (fiscal year 2017 dollars in millions)

	As of 10/2012	Latest 12/2015	Percent change
Research and development cost	$1,032.6	$978.2	-5.3%
Procurement cost	$23,373.8	$19,489.0	-16.6%
Total program cost	$24,444.9	$20,467.2	-16.3%
Program unit cost	$0.447	$0.374	-16.2%
Total quantities	54,730	54,714	0.0%
Acquisition cycle time (months)	125	144	-29.6%

Both JLTV critical technologies—underbelly protection armor and side-kit armor—are mature and, according to officials, have been integrated and tested on production-representative vehicles. During development, operational testers found shortcomings that can likely only be overcome with changes in tactics or procedures. The government conducted design understanding reviews, instead of a formal critical design review, for three competing vehicle designs to assess their technical baselines. To assess manufacturing readiness and risk prior to production start, the program conducted a manufacturing readiness assessment using manufacturing readiness levels. While the program's manufacturing process maturity may have reached DOD's recommended level for production, it has not reached a level that indicates processes are in control, as recommended by best practices.

Attainment of Product Knowledge

As of January 2017	STATUS AT	CURRENT STATUS
Resources and requirements match		
	DEVELOPMENT START	
• Demonstrate all critical technologies are very close to final form, fit, and function within a relevant environment	●	●
• Demonstrate all critical technologies in form, fit and function within a realistic environment	○	●
• Complete a system-level preliminary design review	●	●
Product design is stable		
	DESIGN REVIEW	
• Release at least 90 percent of design drawings	●	▪▪▪▪
• Test a system-level integrated prototype	○	●
Manufacturing processes are mature		
	PRODUCTION START	
• Demonstrate Manufacturing Readiness Level of at least 9 or critical processes are in statistical control	○	○
• Demonstrate critical processes on a pilot production line	●	●
• Test a production-representative prototype	●	●

● Knowledge attained
○ Knowledge not attained
▪▪▪▪ Information not available
▨ Not applicable

JLTV Program

Technology and Design Maturity

According to the program office, JLTV's two critical technologies—underbelly protection armor and side-kit armor—are fully mature. According to Army officials, prototype systems with the critical technologies have been tested in a realistic environment. The JLTV program office declared both technologies are mature and have been demonstrated under operational conditions.

The program office did not hold a formal critical design review during development, but instead conducted design understanding reviews with contractors between December 2012 and January 2013. According to program officials, these reviews were at a level of detail similar to a critical design review and verified that all contractors had more than 90 percent of the design files under configuration control. According to operational testers, the Oshkosh JLTV design, which the Army ultimately selected for production, more than doubles the reliability of the up-armored HMMWV, as measured by average miles traveled before mechanical failure. Testers also noted Army units cannot accomplish air assault missions with JLTVs that already have add-on armor installed because the combined weight exceeds the CH-47F helicopter's lift capacity. However, program officials stated the JLTV requirement for CH-47F air assault missions is with base armor protection and not with the add-on armor installed. Operational testers also noted the JLTV's design did not offer sufficient capability to carry mission equipment, supplies, or water for more than a single day, which limits the vehicle's mission type and duration. This limitation may require operational commanders to manage mission payloads to remain within JLTV's capacities.

Production Maturity

The Army did not demonstrate production readiness with statistical process control data prior to awarding the production contract in August 2015. For the engineering and manufacturing development phase, Oshkosh built 20 prototype JLTV vehicles on an assembly line used to produce the Family of Medium Tactical Vehicles and a version of the Mine-Resistant Ambush Protected vehicle. According to program officials, this quantity was insufficient for providing meaningful statistical control data. To assess production readiness and manufacturing risks prior to production start, the program conducted a manufacturing readiness assessment using manufacturing readiness levels. According to program officials, the contractor has now begun collecting production process capability index data from low-rate production units for statistical control purposes. Also, the design and manufacturing teams continue identifying key product characteristics and manufacturing processes. The program and the contractor are working together to identify critical and significant characteristics for each subsystem, a process the program office says should take a year. While program officials declared manufacturing process maturity reached DOD's recommended level for production, the program has not yet demonstrated that JLTV manufacturing processes are in statistical control as recommended by best practices.

Program Office Comments

In commenting on a draft of this assessment, the program office provided technical comments, which were incorporated where deemed appropriate.

Agency Comments

We provided a draft of this report to DOD for comment. In its comments, reproduced in appendix VII, DOD generally concurred with our observations. DOD also provided us with technical comments, which we incorporated as appropriate.

In its comments, DOD noted that our report identifies many ways in which the department continues to drive down the cost of the acquisition portfolio. Further, DOD stated that our observations appear to validate its focus on continuous improvement on cost, schedule, and performance measures of programs using the “Better Buying Power” and other initiatives. The department also identified plans to publish its own comprehensive report on the acquisition system in the summer of 2017, as it has done in previous years.

We are sending copies of this report to interested congressional committees and offices; the Secretary of Defense; the Secretaries of the Army, Navy, and Air Force; and the Director of the Office of Management and Budget. In addition, the report will be made available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact me at (202) 512-4841. Contact points for our offices of Congressional Relations and Public Affairs may be found on the last page of this report. Staff members making key contributions to this report are listed in appendix VIII.

Michael J. Sullivan
Director, Acquisition and Sourcing Management

List of Committees

The Honorable John McCain
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Thad Cochran
Chairman
The Honorable Richard J. Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Mac Thornberry
Chairman
The Honorable Adam Smith
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Kay Granger
Chairwoman
The Honorable Pete Visclosky
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Scope and Methodology

Analysis of the Cost Performance of DOD's Portfolio of Major Defense Acquisition Programs

To develop our 11 observations on the cost and schedule of the Department of Defense portfolio of current major defense acquisition programs, we obtained and analyzed cost, quantity, and schedule data from Selected Acquisition Reports (SAR) and other information in the Defense Acquisition Management Information Retrieval Purview system, referred to as DAMIR.[1] We entered this data into a database and verified that the data were entered correctly. We converted all cost information to fiscal year 2017 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2017 (table 5-9). To assess the reliability of the SAR data, we reviewed our previous assessment and DOD officials' responses regarding any changes to DAMIR's data quality control procedures. We determined that the SAR data and the information retrieved from DAMIR were sufficiently reliable for the purposes of this report. Our assessment includes comparisons of cost and schedule changes over the past year, 5 years, and from baseline estimates that utilize SAR data from December 2015, December 2014, December 2010, and from the programs' initial SAR submissions. We also analyzed the data to determine the number of programs in each portfolio year. In general, we refer to the 78 major defense acquisition programs with SARs dated December 2015 as DOD's 2016 or current portfolio and use a similar convention for prior year portfolios. We retrieved data on research, development, test, and evaluation; procurement; military construction, acquisition operation and maintenance, and total acquisition costs, as well as schedule estimates for the 78 programs in the 2016 portfolio.[2]

We divided 2 programs into two distinct elements, because DOD reports performance data on them separately. As a result some of our analysis reflects a total of 80 programs and sub-elements. The Missile Defense Agency's Ballistic Missile Defense System and its elements are excluded from all analyses as they do not have an integrated long-term baseline, which prevents us from assessing the program's cost progress or comparing it to other major defense acquisition programs.

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[1] DAMIR Purview is an executive information system operated by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics Acquisition Resources and Analysis.

[2] We refer to research, development, test, and evaluation costs as research and development or simply as development costs in this report. Total acquisition cost includes research and development and procurement costs as well as acquisition related operation and maintenance and system-specific military construction costs.

For our first observation, we compared the 2016 portfolio with the programs that issued SARs in December 2014 (2015 portfolio) to identify the programs that exited and entered the current portfolio and the total cost and schedule change in the current portfolio over the past year.

We then divided the programs into percent cost change categories based on the percent change in total acquisition cost they experienced over the past year. We then totaled the number of programs in each category and the total cost change of the programs in each category.

For the second observation, we identified the development and procurement funding and the change in these over the past year. We identified the specific programs with the largest development and procurement cost increases and whether those were due to quantity changes.

For the third observation, we aggregated funding stream data for the total planned investment of each portfolio from DAMIR for each year since 2006 to determine any trends. We determined the yearly totals for research and development, procurement, and total acquisition cost. To distinguish the funding already invested from the funding remaining that is needed to complete the programs in each portfolio since 2006, we used funding stream data obtained from DAMIR for each December SAR submission for the years 2005 (2006 portfolio) through 2015 (2016 portfolio). We define funding invested as all funding that has been provided to the programs in the fiscal year of the annual SAR submission (this includes fiscal year 2016 for the December 2015 submission) and earlier, while funding remaining is all the amounts that will be provided in the fiscal years after the annual SAR submission (fiscal year 2017 and later for the December 2015 submission).

For our fourth observation, we determined the cost and schedule changes on defense acquisition programs in the current portfolio over the past 5 years and from baseline estimates. To do this, we collected data from December 2015, December 2010, and from programs’ initial SARs; acquisition program baselines; and program offices. In addition, we analyzed programs’ cost growth after three key decision points: development start, critical design review, and production decision.

For programs less than a year old, we calculated the difference between the December 2015 SAR current estimate and the first full estimate in order to identify the cost and schedule change over the past year. For programs less than 5 years old, we took a similar approach when calculating the cost and schedule change over the past 5 years.

For our fifth observation, in order to determine whether programs experienced an increase or decrease in buying power over the past year, we used data on the programs' number of procurement units, procurement cost changes, and average procurement unit costs.

GAO calculated cost change "due" to quantity changes as the change in quantity over the last year multiplied by the average procurement unit cost for the program a year ago. GAO calculated cost change "not due" to quantity changes as the current acquisition quantity times the change in average per unit costs. In practice, changes in quantity will often affect per unit cost—as discussed in this appendix—so this is more precisely described as "Cost change due to change in quantity assuming no change in average procurement unit cost" and "Cost change due to change in average procurement unit cost." If changes in quantity affect per unit cost, those changes will appear in the cost change "not due" to quantity changes.

The resulting dollar amount is considered a change due solely to shifts in the number of units procured and may overestimate the amount of change expected when quantities increase and underestimate the expected change when quantities decrease, as it does not account for other effects of quantity changes on procurement such as gain or loss of learning in production that could result in changes to unit cost over time or the use or absence of economic orders of material. However, these changes are accounted for as part of the change in cost not due to quantities.

For our sixth observation, we evaluated program performance against high-risk criteria discussed by DOD, the Office of Management and Budget, and GAO. We calculated how many programs had less than a 2 percent increase in total acquisition cost over the past year, less than a 10 percent increase over the past 5 years, and less than a 15 percent increase from baseline estimates using data from SARs, initial acquisition program baselines, and program offices. We calculated the percentage of programs meeting each of these high-risk criteria for the 2012-2016 time frame to identify any changes.

For programs with multiple sub-programs presented in the SARs, we calculated the net effect of the sub-programs to reach an aggregate program result.

For our seventh observation, we determined which programs had a first full estimate—or started system development—after the implementation date of Dec. 4, 2009 for the Weapon Systems Acquisition Reform Act of 2009 (WSARA). We then examined these programs cost and schedule changes over the past year as a group.

For our eighth observation, we determined what percent of the portfolio's total acquisition cost was allocated to these programs.

For the ninth observation, we divided these programs into percent cost change categories based on the percent change in total acquisition cost they experienced over the past year. We then totaled the number of programs in each category and the total cost change of the programs in each category.

For our 10th observation, we identified programs initial operational capability and start and end dates of their operational testing. We determined whether the initial operational capability date was before, during, or after its testing dates. Based on our determination, we summed and analyzed what percent of programs were in each category. For some programs, either one or both of these dates were not available.

For the 11th observation, we used SAR data to determine which 25 programs had the largest total acquisition cost, and the prime contractors associated with these programs. We gathered information from Bloomberg on the equity prices of each of these contractors from about 1980 to 2016 from these equities to the S&P 500® and the Industrials sector, as defined by the Standard and Poor's Global Industry Classification Standard.

Analysis of Acquisition Initiatives

To develop observations on how DOD is implementing acquisition reforms, we reviewed the DOD Instruction 5000.02, the Weapon Systems Acquisition Reform Act of 2009 (WSARA), and the September 19, 2014, Under Secretary of Defense for Acquisition, Technology and Logistics "Better Buying Power 3.0 Interim Release" as well as earlier related memoranda.[3] We analyzed questionnaire data received from the 45 current and 9 future major defense acquisition programs in our assessment to determine the extent to which acquisition reforms have

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[3] Pub. L. No. 111-23.

been implemented. We assessed the P-8A Poseidon Multi-Mission Maritime Aircraft Increment 3 as part of the 9 future major defense acquisition programs not yet in the portfolio. During the course of our review, we learned that DOD no longer plans to manage Increment 3 separately from the existing P-8A program. We will reflect this change in future assessments of the P-8A program. We determined which programs have established affordability constraints and, for current programs, examined the average development cost growth on programs with these constraints compared to those without. We tallied programs that conducted "should-cost" analyses and identified realized and/or future potential savings. We also analyzed whether programs are planning for competition throughout the acquisition life-cycle and their plans to evaluate cybersecurity vulnerabilities by 2019.

Analysis of Selected DOD Programs Using Knowledge-Based Criteria and Program Concurrency

To collect data from current and future major defense acquisition programs—including cost and schedule estimates, technology maturity, and planned implementation of acquisition reforms—we distributed one data collection instrument and two electronic questionnaires, one questionnaire for the 45 current programs and a slightly different questionnaire for the 9 future programs. Both of the questionnaires were web-based so that respondents could respond and submit their answers online. We received responses from all of the programs we assessed from August to October 2016. To ensure the reliability of the data collected through the data collection instrument and our questionnaires, we took a number of steps to reduce measurement error and non-response error.

These steps included: conducting three pretests of the future major defense acquisition program questionnaire and three pretests for the current major defense acquisition program questionnaire prior to distribution to ensure that our questions were clear, unbiased, and consistently interpreted; reviewing responses to identify obvious errors or inconsistencies; cross-referencing information provided in the data collection instrument with the questionnaire; and conducting follow-up to clarify responses when needed. Our pretests covered each branch of the military to better ensure that the questionnaires could be understood by officials within each branch.

Our analysis of how well programs are adhering to a knowledge-based acquisition approach focuses on 45 major defense acquisition programs that are mostly in development or the early stages of production. To assess the knowledge attained by key decision points (system development start or detailed design contract award for shipbuilding programs, critical design review or fabrication start for shipbuilding programs, and production start), we collected data from program offices about their knowledge at each point.[4] In particular, we focused on the 11 programs that crossed these key acquisition points in 2016 or planned to in early 2017 and evaluated their adherence to knowledge-based practices.

We also provide information on how much knowledge is obtained at key decision points by programs which accomplished these previously. We also included observations on the knowledge that 9 future programs expect to obtain before starting development. We did not validate the data provided by the program offices, but reviewed the data and performed various checks to determine that they were reliable enough for our purposes. Where we discovered discrepancies, we clarified the data accordingly.

For programs that have passed a key decision point and have since been restructured, we will continue to assess them against their original cost and schedule estimates at that milestone or decision point, such as development start. We will not reassess a program at milestones that have already been reached if a program is repeating a key decision point or milestone such as milestone B. We will keep our original assessment of the program's knowledge attained at the original milestone. However, we will change a future milestone date if that milestone had not yet been reached and assess the program for its implementation of our best practices at that point in time.

The 54 current and future programs included in our assessment were in various stages of the acquisition cycle, and not all of the programs provided information on knowledge obtained at each point. Programs were not included in our assessments at key decision points if relevant data were not available. Our analysis of knowledge attained at each key point includes factors that we have previously identified as being key to a

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[4] Analysis of shipbuilding programs for technology maturity and design maturity differ as shipbuilding programs must meet these metrics at different points in the acquisition cycle according to GAO's methodology for ships (see GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding,* GAO-09-322 (Washington, D.C.: May, 13, 2009). As a result best practices for a knowledge based acquisition approach differ for shipbuilding programs. For these reasons, we exclude the six shipbuilding programs in DOD's portfolio from parts of our analysis at each of the three key decision points.

knowledge-based acquisition approach, including holding early systems engineering reviews, testing an integrated prototype prior to the design review, using a reliability growth curve, planning for manufacturing, and testing a production-representative prototype prior to the making a production decision. Additional information on how we collect these data is found in the product knowledge assessment section of this appendix. See also appendix IV for a list of the practices that are associated with a knowledge-based acquisition approach.

To assess program development testing and production concurrency, we identified the programs—among those we included in our assessment—with production start dates. We used the questionnaire responses from those programs to identify the dates for the start and end of developmental testing, compared those dates to the timing of each program's production decision and determined the number of months, if any, of developmental testing done after production start. We then compared the number of overlapping months to the total number of months of developmental testing for each program and calculated the percentage of developmental testing done concurrent with production.

To examine programs' software development efforts, we identified the programs that reported their software as high-risk. We used the questionnaire responses from these programs to assess the reasons why they identified their software effort as high-risk. We identified the dates reported by programs for their software and hardware integration and compared those dates to each program's production start date to assess each programs' degree of software development and production concurrency.

Individual Assessments of Weapon Programs

This report presents individual assessments of 54 current and future weapon programs. In addition, we assessed the Navy's Frigate initiative separate from the Navy's Littoral Combat Ship program, given DOD's plans to restructure the Frigate into a separate program soon. A table listing these assessments is found in appendix VIII.

Of our 55 total assessments, 43 are captured in a two-page format discussing technology, design, and manufacturing knowledge obtained and other program issues. These two-page assessments are of major defense acquisition programs, most of which are in development or early production. The remaining 12 assessments are described in a one-page format that describes their current status. Those one-page assessments include (1) nine future major defense acquisition programs; (2) two major defense acquisition programs that are well into production but planning to introduce new increments of capability—the DDG-51 Flight III and P-8A Increment 3 modification programs; and (3) the Navy's Frigate initiative. For presentation purposes we grouped the individual assessments by lead service—Army, Navy and Marine Corps, Air Force, and DOD-led—and inserted a lead service separator page at the start of each grouping. These four separator pages summarize information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained that is provided in the one and two-page assessments. We report cost and schedule growth in the separator pages in a manner that is consistent with how it is reported and described elsewhere in the report. Estimates of funding needed to complete in the separator pages are based on all amounts that will be provided in fiscal year 2017 and later. For some future major defense acquisition programs, the estimates of funding needed represents only those amounts provided through fiscal year 2021 and are not the full amount needed to complete the acquisition.

Over the past several years, DOD has revised policies governing weapon system acquisitions and changed the terminology used for major acquisition events. To make DOD's acquisition terminology more consistent across our individual program assessments, we standardized the terminology for key program events. For most individual programs in our assessment, “development start” refers to the initiation of an acquisition program as well as the start of engineering and manufacturing development or system development. This generally coincides with DOD's milestone B. A few programs in our assessment have a separate “program start” date, which begins a pre–system development phase for program definition and risk-reduction activities. This “program start” date generally coincides with DOD's former terminology for milestone I or DOD's current milestone A, which denotes the start of technology maturation and risk reduction. The “production decision” generally refers to the decision to enter the production and deployment phase, typically with low-rate initial production. The “initial capability” refers to the initial operational capability—sometimes called first unit equipped or required asset availability. For shipbuilding programs, the schedule of key program events in relation to acquisition milestones varies for each program. Our work on shipbuilding best practices has identified the detail design contract award and the start of lead ship fabrication as the points in the acquisition process roughly equivalent to development start and design review for other programs.

For each program we assessed in a two-page format, we present cost, schedule, and quantity data at the program's first full estimate, and an estimate from the latest SAR or the program office reflecting 2016 data where they were available. The first full estimate is generally the cost estimate established at milestone B—development start; however, for a few programs that did not have such an estimate, we used the estimate at milestone C—production start—instead. For shipbuilding programs, we used their planning estimates if those estimates were available. For systems for which a first full estimate was not available, we only present the latest available estimate of cost and quantities. For the other programs assessed in a one-page format, we present the latest available estimate of cost and quantity from the program office.

For each program we assessed, all cost information is presented in fiscal year 2017 dollars. We converted cost information to fiscal year 2017 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2017 (table 5-9). We have depicted only the program's main elements of acquisition cost—research and development and procurement. However, the total program cost also includes military construction and acquisition-related operation and maintenance costs. Because of rounding and these additional costs, in some situations, total cost may not match the exact sum of the research and development and procurement costs. The program unit costs are calculated by dividing the total program cost by the total quantities planned. These costs are often referred to as program acquisition unit costs. In some instances, the data were not applicable, and we annotate this by using the term "not applicable (NA)." The quantities listed refer to total quantities, including both procurement and development quantities.

The schedule assessment for each program is based on acquisition cycle time, defined as the number of months between program start and the achievement of initial operational capability or an equivalent fielding date. In some instances the data were not yet available, and we annotate this by using the term "to be determined (TBD)" or "NA."

The information presented on the "funding needed to complete" is from fiscal year 2017 through completion and, unless otherwise noted, draws on information from SARs or on data from the program office. In some instances, the data were not available, and we annotate this by the term "TBD" or "NA." The quantities listed refer only to procurement quantities. Satellite programs, in particular, produce a large percentage of their total operational units as development quantities, which are not included in the quantity figure.

The intent of these comparisons is to provide an aggregate, or overall, picture of a program's history. These assessments represent the sum of the federal government's actions on a program, not just those of the program manager and the contractor. DOD does a number of detailed analyses of changes that attempt to link specific changes with triggering events or causes. Our analysis does not attempt to make such detailed distinctions.

In this year's assessment, we also reviewed whether individual subcontracting reports from a program's prime contractor or contractors were accepted on the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 78 of the major defense acquisition programs included in our assessment using the contract information reported in their December 2015 Selected Acquisition Reports. See appendix VI for a list of the programs we reviewed.

Product Knowledge Data on Individual Two-Page Assessments

In our past work examining weapon acquisition issues and best practices for product development, we have found that leading commercial firms pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated by critical points in the acquisition process. On the basis of this work, we have identified three key knowledge points during the acquisition cycle—system development start, critical design review, and production start—at which programs need to demonstrate critical levels of knowledge to proceed. To assess the product development knowledge of each program at these key points, we reviewed data-collection instruments and questionnaires submitted by programs; however, not every program had responses to each element of the data-collection instrument or questionnaire. We also reviewed pertinent program documentation and discussed the information presented on the data-collection instrument and questionnaire with program officials as necessary.

In this year's report we have made a change to our attainment of product knowledge graphic. In addition to assessing programs' current status in achieving the product knowledge criteria, we now also show programs' progress in meeting the knowledge attainment criteria at the time they reached the three key knowledge points during the acquisition cycle—system development start, critical design review, and production start. For programs that have passed a key decision point and have since been restructured, we continue to assess them against their original cost and schedule estimates at that milestone or decision point, such as development start. We have not reassessed a program at milestones that have already been reached if a program is repeating a key decision point or milestone, such as milestone B. We have kept our original assessment of the program's knowledge attained at the original milestone. However, we have changed future milestone dates in instances when the program had not yet reached the affected milestone. In these instances, we assessed the program for its implementation of our best practices at that point in time.

To assess a program's readiness to enter system development, we collected data through the data-collection instrument on critical technologies and early design reviews. To assess technology maturity, we asked program officials to apply a tool, referred to as technology readiness levels (TRL), for our analysis. The National Aeronautics and Space Administration originally developed TRLs, and the Army and Air Force science and technology research organizations use them to determine when technologies are ready to be handed off from science and technology managers to product developers. TRLs are measured on a scale from 1 to 9, beginning with paper studies of a technology's feasibility and culminating with a technology fully integrated into a completed product. See appendix V for TRL definitions. Our best-practices work has shown that a TRL 7—demonstration of a technology in its final form, fit, and function within a realistic environment—is the level of technology maturity that constitutes a low risk for starting a product development program.[5] For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detail design.[6] In our assessment, the technologies that have reached TRL 7, a prototype demonstrated in an operational environment, are referred to as mature or fully mature. Those technologies that have reached TRL 6, a prototype very close to final form, fit, and function demonstrated within a relevant environment, are referred to as approaching or nearing maturity. Satellite technologies that have achieved TRL 6 are assessed as fully mature due to the difficulty of demonstrating maturity in an operational environment—space. In addition, we asked program officials to provide the date of the system-

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[5] GAO, *Best Practices: Better Matching of Needs and Resources Will Lead to Better Weapon System Outcomes*, GAO-01-288 (Washington, D.C.: Mar. 8, 2001); and *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999).

[6] GAO, *Best Practices: High Levels of Knowledge at Key Points Differentiate Commercial Shipbuilding from Navy Shipbuilding*, GAO-09-322 (Washington, D.C.: May 13, 2009).

level preliminary design review. We compared this date to the system development start date.

In most cases, we did not validate the program offices' selection of critical technologies or the determination of the demonstrated level of maturity. We sought to clarify the TRLs in those cases where information existed that raised concerns. If we were to conduct a detailed review, we might adjust the critical technologies assessed, their readiness levels demonstrated, or both. It was not always possible to reconstruct the technological maturity of a weapon system at key decision points after the passage of many years. Where practicable, we compared technology assessments provided by the program office to assessments conducted by officials from the Office of the Assistant Secretary of Defense for Research and Engineering.

To assess design stability, we asked program officials to provide the percentage of design drawings completed or projected for completion by the design review, the production decision, and as of our current assessment in the data-collection instrument. In most cases, we did not verify or validate the percentage of engineering drawings provided by the program office. We clarified the percentage of drawings completed in those cases where information that raised concerns existed. Completed drawings were defined as the number of drawings released or deemed releasable to manufacturing that can be considered the "build to" drawings. For shipbuilding programs, we asked program officials to provide the percentage of the three-dimensional product model that had been completed by the start of lead ship fabrication, and as of our current assessment. To gain greater insights into design stability, we also asked program officials to provide the date they planned to first integrate and test all key subsystems and components into a system-level integrated prototype. We compared this date to the date of the design review. We did not assess whether shipbuilding programs had completed integrated prototypes.

To assess production maturity, we asked program officials for their Manufacturing Readiness Level (MRL) for process capability and control or to identify the number of critical manufacturing processes and, where available, to quantify the extent of statistical control achieved for those processes as a part of our data-collection instrument. In most cases, we did not verify or validate the information provided by the program office. We clarified the number of critical manufacturing processes and the percentage of statistical process control where information existed that raised concerns. We used a standard called the Process Capability Index, a process-performance measurement that quantifies how closely a process is running to its specification limits. The index can be translated into an expected product defect rate, and we have found it to be a best practice. We also used data provided by the program offices on their MRL for process capability and control, a sub-thread tracked as part of the manufacturing readiness assessment process recommended by DOD, to determine production maturity. We assessed programs as having mature manufacturing processes if they reported an MRL 9 for that sub-thread—meaning, that manufacturing processes are stable, adequately controlled, and capable. To gain further insights into production maturity, we asked program officials whether the program planned to demonstrate critical manufacturing processes on a pilot production line before beginning low-rate production. We also asked programs on what date they planned to begin system-level developmental testing of a fully configured, production-representative prototype in its intended environment. We compared this date to the production start date. We did not assess production maturity for shipbuilding programs.

Although the knowledge points provide excellent indicators of potential risks, by themselves they do not cover all elements of risk that a program encounters during development, such as funding instability. Our detailed reviews on individual systems normally provide a more comprehensive assessment of risk elements.

We conducted this performance audit from April 2016 to March 2017 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Current and First Full Estimates for DOD's 2016 Portfolio of Major Defense Acquisition Programs

Table 6 contains the current and first full total acquisition cost estimates (in fiscal year 2017 dollars) for each program or element in the Department of Defense's (DOD) 2016 major defense acquisition program portfolio. For each program we show the percent change in total acquisition cost from the first full estimate, as well as over the past year and 5 years.

Table 6: Current Cost Estimates and First Full Estimates for DOD's 2016 Portfolio of Major Defense Acquisition Programs

Fiscal year 2017 dollars (in millions)

Program Name	Current total acquisition cost	First Full Estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
Advanced Extremely High Frequency (AEHF) Satellite	$15,046	$6,910	117.7%	0.6%	-1.5%
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	2,731	1,736	57.3	18.8	32.4
AH-64E Apache New Build (AH-64E New Build)	2,264	2,570	-11.9	-3.4	-5.8
AH-64E Apache Remanufacture (AH-64E Remanufacture)	14,104	7,855	79.6	-0.3	21.1
AIM-9X Block II Sidewinder (AIM-9X Blk II)	3,821	4,333	-11.8	7.8	-11.8
Air and Missile Defense Radar (AMDR)	5,426	6,064	-10.5	2.6	-10.5
Airborne and Maritime/Fixed Station (AMF)	3,314	8,845	-62.5	-8.7	-62.8
Armored Multi-Purpose Vehicle (AMPV)	11,074	11,049	0.2	0.2	0.2
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	24,687	11,854	108.3	-2.6	-3.5
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	2,849	3,029	-5.9	-0.7	-5.9
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)	594	770	-22.8	-0.1	-12.3
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	1,281	1,418	-9.6	-8.0	-9.7
C-130J Hercules Transport Aircraft (C-130J)	17,315	1,029	1582.0	0.4	3.7
C-5 Reliability Enhancement and Re-engining Program (C-5 RERP)	7,636	11,828	-35.5	-0.2	-5.4
Cooperative Engagement Capability (CEC)	6,201	3,193	94.2	6.2	9.8
CH-47F Improved Cargo Helicopter (CH-47F)	16,080	3,492	360.4	-0.8	2.4
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	26,252	17,958	46.2	1.0	7.9

Fiscal year 2017 dollars (in millions)

Program Name	**Current total acquisition cost**	**First Full Estimate total acquisition cost**	**Change in total acquisition cost from first full estimate (percent)**	**Change in total acquisition cost within the past year (percent)**	**Change in total acquisition cost within the past 5 years (percent)**
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	11,226	2,866	291.7	0.3	1.7
Combat Rescue Helicopter (CRH)	8,532	8,427	1.2	0.2	1.2
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	37,540	38,587	-2.7	1.9	1.8
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	23,646	37,751	-37.4	1.4	3.9
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	122,689	16,474	644.8	5.4	11.1
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	21,939	16,001	37.1	0.8	14.0
EA-18G Growler Aircraft (EA-18G)	16,756	9,736	72.1	8.3	35.4
Evolved Expendable Launch Vehicle (EELV)	59,638	18,848	216.4	-2.5	61.4
Enhanced Polar System (EPS)	1,438	1,447	-0.6	-0.2	-0.6
Excalibur Precision 155mm Projectiles (Excalibur)	2,045	5,181	-60.5	3.1	4.0
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1,587	1,626	-2.4	0.3	-2.4
F-35 Lightning II Program (F-35)	336,152	231,806	45.0	-2.2	-5.1
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	4,519	3,459	30.7	3.8	-7.5
MQ-8 (Fire Scout)	2,935	2,837	3.5	-0.5	3.5
Ground/Air Task Oriented Radar (G/ATOR)	2,818	1,590	77.3	0.4	77.3
Global Broadcast Service (GBS)	1,341	625	114.6	2.7	7.3
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	6,843	1,918	256.8	-1.4	8.3
Global Positioning System III (GPS III)	5,772	4,275	35.0	16.1	22.8
Next Generation Operational Control System (GPS OCX)	4,353	3,592	21.2	15.2	21.2
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	13,241	3,934	236.6	-0.9	-2.8
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	14,343	9,072	58.1	-1.6	1.0
Integrated Air and Missile Defense (IAMD)	6,501	5,454	19.2	0.9	8.4
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	1,908	1,890	1.0	0.3	1.0

Fiscal year 2017 dollars (in millions)

Program Name	**Current total acquisition cost**	**First Full Estimate total acquisition cost**	**Change in total acquisition cost from first full estimate (percent)**	**Change in total acquisition cost within the past year (percent)**	**Change in total acquisition cost within the past 5 years (percent)**
Integrated Defensive Electronic Countermeasures (IDECM) Sum	3,031	2,362	28.4	11.9	17.5
IDECM Block 4	1,195	753	58.7	28.0	34.1
IDECM Blocks 2/3	1,836	1,608	14.2	3.4	8.7
Joint Air-to-Ground Missile (JAGM)	5,854	5,841	0.2	0.2	0.2
Joint Air-to-Surface Standoff Missile (JASSM)	7,486	4,960	50.9	0.8	-8.1
JASSM Baseline	3,363	2,514	33.8	1.5	-18.0
JASSM Extended Range (JASSM-ER)	4,123	2,446	68.6	0.2	1.9
Joint Direct Attack Munition (JDAM)	9,998	3,709	169.6	7.4	40.1
Joint Light Tactical Vehicle (JLTV)	20,467	24,445	-16.3	-15.5	-16.3
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	1,965	1,098	79.0	22.2	84.3
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	9,564	10,888	-12.2	3.6	63.8
KC-130J Transport Aircraft (KC-130J)	9,675	10,288	-6.0	-1.7	-5.0
KC-46A Tanker Modernization Program (KC-46A)	43,627	47,535	-8.2	-0.9	-8.2
Littoral Combat Ship (LCS)	26,650	2,434	994.8	25.8	-25.3
Littoral Combat Ship - Mission Modules (LCS Packages)	7,101	7,108	-0.1	1.4	-0.1
LHA 6 America Class Amphibious Assault Ship (LHA 6)	9,989	3,449	189.6	-0.9	-8.8
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	21,502	12,705	69.2	-0.1	6.1
M109A7 Family of Vehicles (M109A7 FOV)	7,405	7,254	2.1	1.7	2.1
MH-60R Multi-Mission Helicopter (MH-60R)	14,670	6,004	144.3	-0.4	-8.0
Multifunctional Information Distribution System (MIDS)	5,019	1,414	254.8	21.1	53.0
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	5,377	1,101	388.2	1.3	-3.9
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	13,123	13,936	-5.8	1.3	-7.3
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	12,018	2,860	320.2	-2.2	-6.8
Mobile User Objective System (MUOS)	7,403	7,291	1.5	-5.1	-2.2

Fiscal year 2017 dollars (in millions)

Program Name	Current total acquisition cost	First Full Estimate total acquisition cost	Change in total acquisition cost from first full estimate (percent)	Change in total acquisition cost within the past year (percent)	Change in total acquisition cost within the past 5 years (percent)
Navy Multiband Terminal (NMT)	2,314	2,518	-8.1	7.3	13.4
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	33,477	33,665	-0.6	-0.5	-6.4
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	6,538	7,905	-17.3	1.8	-24.1
Remote Minehunting System (RMS)	886	1,564	-43.3	-44.3	-42.2
Space Based Infrared System High (SBIRS High)	19,184	4,986	284.7	-0.8	-3.6
Small Diameter Bomb Increment II (SDB II)	4,296	5,100	-15.8	7.0	-15.7
Standard Missile-6 (SM-6)	9,195	6,183	48.7	1.5	34.6
Space Fence Ground-Based Radar System Increment 1	1,553	1,632	-4.8	-3.2	-4.8
Ship to Shore Connector Amphibious Craft (SSC)	4,000	4,288	-6.7	-3.2	-6.7
SSN 774 Virginia Class Submarine (SSN 774)	95,599	65,574	45.8	3.7	5.2
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	6,987	2,295	204.4	10.5	-7.2
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	58,527	51,207	14.3	0.2	1.4
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	26,488	14,069	88.3	-0.3	-3.0
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	63,534	43,501	46.1	1.5	2.4
VH-92A Presidential Helicopter Replacement Program	4,819	4,842	-0.5	-1.1	-0.5
Wideband Global SATCOM (WGS)	4,269	1,295	229.7	2.8	7.1
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	10,680	4,022	165.5	1.3	62.7
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	2,038	17,754	-88.5	-0.4	-86.5

Source: GAO analysis of DOD data. | GAO-17-333SP

Notes: Data were obtained from DOD's Selected Acquisition Reports, acquisition program baselines, and, in some cases, program offices.

Appendix III: Changes in DOD's 2016 Portfolio of Major Defense Acquisition Programs over 5 Years and Since First Full Estimates

Table 7 shows the change in research and development cost, procurement cost, total acquisition cost, and average delay in delivering initial operational capability for those programs in the Department of Defense's (DOD) 2016 portfolio over the last 5 years and since their first full cost and schedule estimates.

Table 7: Cost and Schedule Changes for Programs in DOD's 2016 Portfolio

Fiscal year 2017 dollars (in billions)

	5 year comparison (2011-2016)	Since first full estimate (baseline to 2016)
Change in total research and development cost	12.2	100.5
	4.4%	53.2%
Change in total procurement cost	-5.5	381.5
	-0.5%	48.9%
Change in total other acquisition costs[a]	1.9	2.3
	16.5%	21.3%
Change in total acquisition cost	8.6	484.3
	0.6%	49.4%
Average delay in delivering initial capabilities	11.0 months	30.8 months
	13.4%	40.0%

Source: GAO analysis of DOD data. | GAO-17-333SP

Notes: Data were obtained from DOD's Selected Acquisition Reports and acquisition program baselines. In a few cases data were obtained directly from program offices. Some numbers may not sum due to rounding.

[a] Other total acquisition costs include acquisition-related operation and maintenance and system-specific military construction costs.

Appendix IV: Knowledge-Based Acquisition Practices

GAO’s prior work on best product-development practices found that successful programs take steps to gather knowledge that confirm that their technologies are mature, their designs stable, and their production processes are in control. Successful product developers ensure a high level of knowledge is achieved at key junctures in development. We characterize these junctures as knowledge points. The Related GAO Products section of this report includes references to the body of work that helped us identify these practices and apply them as criteria in weapon system reviews. The following table summarizes these knowledge points and associated key practices.

Table 8: Best Practices for Knowledge-based Acquisitions

Knowledge Point 1: Technologies, time, funding, and other resources match customer needs. Decision to invest in product development
Demonstrate technologies to a high readiness level—Technology Readiness Level 7—to ensure technologies will work in an operational environment [a]
Ensure that requirements for product increment are informed by preliminary design review using systems engineering process (such as prototyping of preliminary design)
Establish cost and schedule estimates for product on the basis of knowledge from preliminary design using systems engineering tools (such as prototyping of preliminary design)
Constrain development phase (5 to 6 years or less) for incremental development
Ensure development phase fully funded (programmed in anticipation of milestone)
Align program manager tenure to complete development phase
Contract strategy that separates system integration and system demonstration activities
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review for development start
Knowledge Point 2: Design is stable and performs as expected. Decision to start building and testing production-representative prototypes
Complete system critical design review
Complete 90 percent of engineering design drawing packages
Complete subsystem and system design reviews
Demonstrate with system-level integrated prototype that design meets requirements
Complete the failure modes and effects analysis
Identify key system characteristics
Identify critical manufacturing processes
Establish reliability targets and growth plan on the basis of demonstrated reliability rates of components and subsystems
Conduct independent cost estimate
Conduct independent program assessment

Conduct major milestone decision review to enter system demonstration
Knowledge Point 3: Production meets cost, schedule, and quality targets. Decision to produce first units for customer
Demonstrate manufacturing processes
Build and test production-representative prototypes to demonstrate product in intended environment
Test production-representative prototypes to achieve reliability goal
Collect statistical process control data
Demonstrate that critical processes are capable and in statistical control
Conduct independent cost estimate
Conduct independent program assessment
Conduct major milestone decision review to begin production

Source: GAO. | GAO-17-333SP

[a] DOD considers Technology Readiness Level 6, demonstrations in a relevant environment, to be appropriate for programs entering system development; therefore we have analyzed programs against this measure as well.

Appendix V: Technology Readiness Levels

Table 9: Technology Readiness Levels and Descriptions

Technology readiness level	Description	Hardware/software	Demonstration environment
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties	None (paper studies and analysis)	None
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.	None (paper studies and analysis)	None
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.	Analytical studies and demonstration of non-scale individual components (pieces of subsystem)	Lab
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.	Low-fidelity breadboard. Integration of non-scale components to show pieces will work together. Not fully functional or form or fit but representative of technically feasible approach suitable for flight articles.	Lab
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include "high fidelity" laboratory integration of components.	High-fidelity breadboard. Functionally equivalent but not necessarily form and/or fit (size weight, materials, etc.). Should be approaching appropriate scale. May include integration of several components with reasonably realistic support elements/subsystems to demonstrate functionality.	Lab demonstrating functionality but not form and fit. May include flight demonstrating breadboard in surrogate aircraft. Technology ready for detailed design studies.

Technology readiness level		Description	Hardware/software	Demonstration environment
6.	System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated realistic environment.	Prototype. Should be very close to form, fit and function. Probably includes the integration of many new components and realistic supporting elements/subsystems if needed to demonstrate full functionality of the subsystem.	High-fidelity lab demonstration or limited/restricted flight demonstration for a relevant environment. Integration of technology is well defined.
7.	System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in a realistic environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft.	Prototype. Should be form, fit and function integrated with other key supporting elements/subsystems to demonstrate full functionality of subsystem.	Flight demonstration in representative realistic environment such as flying test bed or demonstrator aircraft. Technology is well substantiated with test data.
8.	Actual system completed and "flight qualified" through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.	Flight-qualified hardware	Developmental Test and Evaluation in the actual system application.
9.	Actual system "flight proven" through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.	Actual system in final form	Operational Test and Evaluation in operational mission conditions.

Source: GAO and its analysis of National Aeronautics and Space Administration data. | GAO-17-333SP

Appendix VI: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System

Table 10 shows the number of prime contractors for the programs we assessed where an individual subcontracting report is reported as acknowledged during 2016 in the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 78 major defense acquisition programs included in our assessment that reported prime contract information in their December 2015 Selected Acquisition Report (SAR) submissions. The government uses individual subcontracting reports from eSRS as one method of monitoring small business participation, as this tool includes information on contractors' performance against small business subcontracting goals. There are multiple reasons why a prime contractor may not have an acknowledged subcontracting report in eSRS. For example, some contractors may have pending or rejected reports within the system, as all reports are reviewed prior to acknowledgment. Not all prime contracts for major defense acquisition programs are required to submit individual subcontracting reports. For example, some contractors report small business participation at a corporate level as opposed to the program level, and this data is not captured in the individual subcontracting reports.[1] In addition, although a prime contractor may be required to submit a report, it may not yet have done so for the period we reviewed.[2]

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[1] As of December 2016, 10 major defense companies were participating in the Test Program for Negotiation of Comprehensive Small Business Subcontracting Plans created by the National Defense Authorization Act for Fiscal Years 1990 and 1991 Pub. L. No. 101-189, § 834 (1989). These major defense companies have each established a comprehensive subcontracting plan on a corporate, division or plant-wide basis under which a single summary subcontract report is submitted semi-annually for any covered DOD contracts. The test program has been extended by Congress several times with the current three year extension made by the Carl Levin and Howard P. "Buck" McKeon National Defense Authorization Act for Fiscal Year 2015, Pub. L. No. 113-291 § 821 (2014) to end on December 31, 2017. Participation in the test program is on a voluntary basis such that these major defense companies may have contracts where they are reporting on an individual basis as well as contracts where they are reporting on a comprehensive basis.

[2] For further information on the limitations of eSRS and other contract reporting systems, see GAO, *Federal Subcontracting: Linking Small Business Subcontractors to Prime Contracts Is Not Feasible Using Current Systems*, GAO-15-116 (Washington, D.C.: Dec. 11, 2014).

Table 10: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System

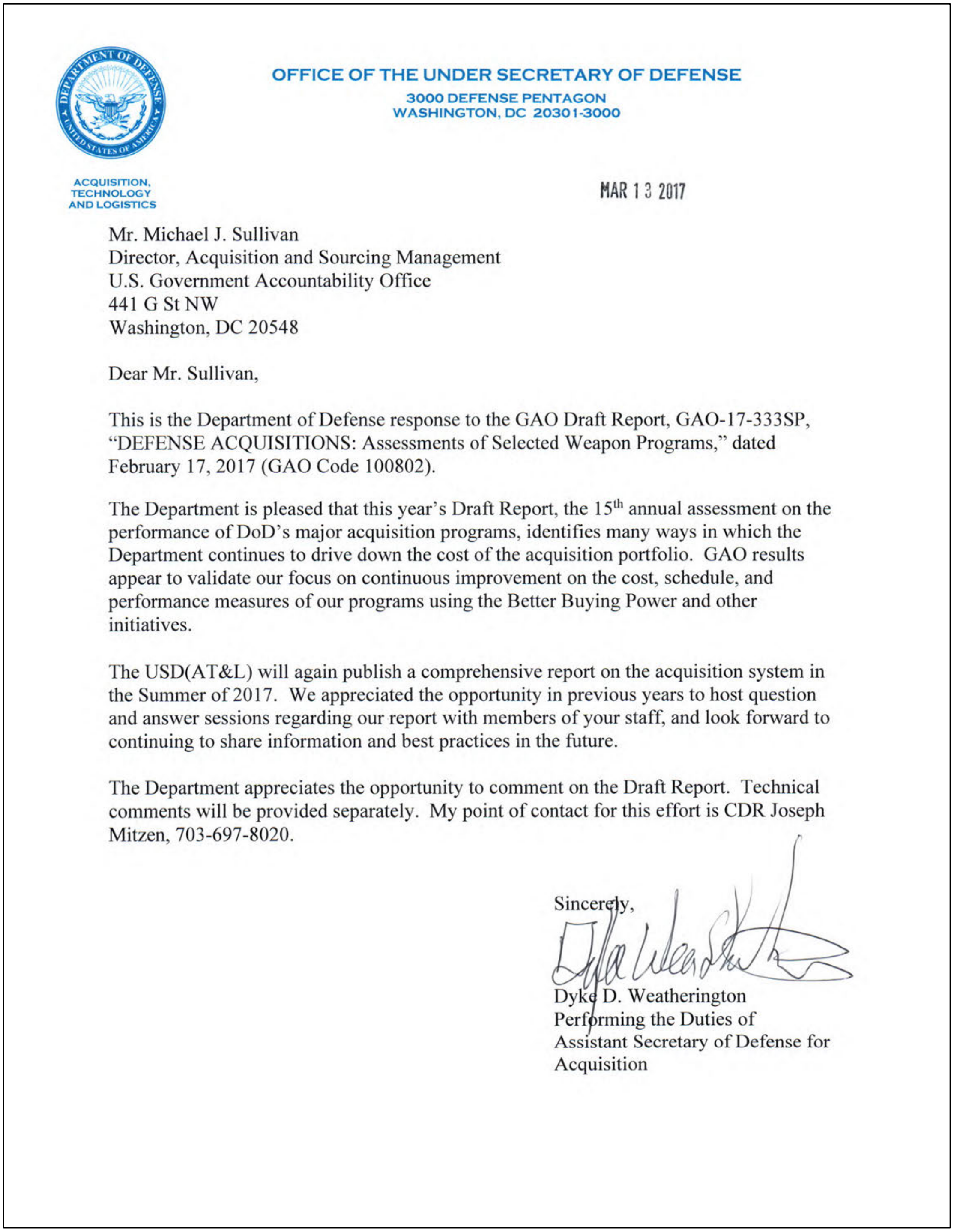
Program name	Number of contracts listed in the December 2015 SAR	Contracts with an accepted individual subcontracting report (as of October 2016)
Advanced Extremely High Frequency (AEHF) Satellite	2	0
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	3	2
AH-64E Apache New Build (AH-64E New Build)	1	1
AH-64E Apache Remanufacture (AH-64E Remanufacture)	6	3
AIM-9X Block II Sidewinder (AIM-9X Blk II)	6	0
Air and Missile Defense Radar (AMDR)	1	0
Airborne and Maritime/Fixed Station (AMF)	0	0
Armored Multi-Purpose Vehicle (AMPV)	1	1
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	5	0
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	1	0
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)	1	1
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	1	1
C-130J Hercules Transport Aircraft (C-130J)	9	1
C-5 Reliability Enhancement and Re-engining Program (C-5 RERP)	1	0
Cooperative Engagement Capability (CEC)	5	0
CH-47F Improved Cargo Helicopter (CH-47F)	1	0
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	2	0
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	2	0
Combat Rescue Helicopter (CRH)	1	0
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	4	3
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	2	2
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	5	5
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	6	4
EA-18G Growler Aircraft (EA-18G)	6	3
Evolved Expendable Launch Vehicle (EELV)	4	2
Enhanced Polar System (EPS)	1	1
Excalibur Precision 155mm Projectiles (Excalibur)	0	0
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1	0
F-35 Lightning II Program (F-35)	6	0
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	2	0
Ground/Air Task Oriented Radar (G/ATOR)	2	0

Program name	Number of contracts listed in the December 2015 SAR	Contracts with an accepted individual subcontracting report (as of October 2016)
Global Broadcast Service (GBS)	1	0
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	5	0
Global Positioning System III (GPS III)	2	0
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	4	3
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	2	0
Integrated Air and Missile Defense (IAMD)	2	1
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	1	0
Integrated Defensive Electronic Countermeasures (IDECM) Block 4	4	2
Joint Air-to-Ground Missile (JAGM)	1	0
Joint Air-to-Surface Standoff Missile (JASSM)	3	0
Joint Direct Attack Munition (JDAM)	1	1
Joint Light Tactical Vehicle (JLTV)	1	1
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	1	0
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	2	2
KC-130J Transport Aircraft (KC-130J)	5	1
KC-46A Tanker Modernization Program (KC-46A)	4	3
Littoral Combat Ship (LCS)	2	1
Littoral Combat Ship - Mission Modules (LCS Packages)	0	0
LHA 6 America Class Amphibious Assault Ship (LHA 6)	1	1
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	1	1
MH-60R Multi-Mission Helicopter (MH-60R)	4	0
Multifunctional Information Distribution System (MIDS)	6	4
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	4	4
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	1	1
MQ-8 Fire Scout	1	1
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	2	0
Mobile User Objective System (MUOS)	1	0
Navy Multiband Terminal (NMT)	2	0
Next Generation Operational Control System (GPS OCX)	0	0
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	2	1
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	3	0
M109A7 Family of Vehicles (M109A7 FOV)	0	0
Remote Minehunting System (RMS)	0	0
Space Based Infrared System High (SBIRS High)	4	0

Program name	Number of contracts listed in the December 2015 SAR	Contracts with an accepted individual subcontracting report (as of October 2016)
Small Diameter Bomb Increment II (SDB II)	1	0
Standard Missile-6 (SM-6)	3	0
Space Fence Ground-Based Radar System Increment 1	1	0
Ship to Shore Connector Amphibious Craft (SSC)	1	1
SSN 774 Virginia Class Submarine (SSN 774)	2	2
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	2	0
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	11	0
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	1	0
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	3	0
VH-92A Presidential Helicopter Replacement Program	1	0
Wideband Global SATCOM (WGS)	1	1
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	1	0
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	1	0
Totals	**190**	**62**

Source: GAO analysis of data from DOD and eSRS. | GAO-17-333SP

Appendix VII: Comments from the Department of Defense



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

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

MAR 13 2017

Mr. Michael J. Sullivan
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G St NW
Washington, DC 20548

Dear Mr. Sullivan,

This is the Department of Defense response to the GAO Draft Report, GAO-17-333SP, "DEFENSE ACQUISITIONS: Assessments of Selected Weapon Programs," dated February 17, 2017 (GAO Code 100802).

The Department is pleased that this year's Draft Report, the 15th annual assessment on the performance of DoD's major acquisition programs, identifies many ways in which the Department continues to drive down the cost of the acquisition portfolio. GAO results appear to validate our focus on continuous improvement on the cost, schedule, and performance measures of our programs using the Better Buying Power and other initiatives.

The USD(AT&L) will again publish a comprehensive report on the acquisition system in the Summer of 2017. We appreciated the opportunity in previous years to host question and answer sessions regarding our report with members of your staff, and look forward to continuing to share information and best practices in the future.

The Department appreciates the opportunity to comment on the Draft Report. Technical comments will be provided separately. My point of contact for this effort is CDR Joseph Mitzen, 703-697-8020.

Sincerely,

Dyke D. Weatherington
Performing the Duties of
Assistant Secretary of Defense for
Acquisition

Appendix VIII: GAO Contact and Staff Acknowledgments

GAO Contact

Michael J. Sullivan, (202) 512-4841 or sullivanm@gao.gov

Staff Acknowledgments

Principal contributors to this report were Christopher R. Durbin, Assistant Director; Desirée E. Cunningham; Matthew T. Drerup; Danny G. Owens; Wendy P. Smythe; Patrick R. Tierney; and J. Andrew Walker. Other key contributors included, Matthew Ambrose, Cheryl K. Andrew, Sonja J. Bensen, David B. Best, Emily Bond, Edwin B. Booth, Julie C. Hadley, Rich Horiuchi, J. Kristopher Keener, Julia Kennon, Jill N. Lacey, Katherine Lenane, Travis J. Masters, LaTonya D. Miller, Diana Moldafsky, Meghan C. Perez, Beth Reed Fritts, Max B. Sawicky, Ronald E. Schwenn, William Shear, Charlie Shivers, Roxanna T. Sun, Jay Tallon, Bruce H. Thomas, Kristin VanWychen, and Alyssa B. Weir.

Table 11 lists the staff responsible for individual programs:

Table 11: Staff Responsible for Individual Program Assessments

Program name	Primary staff
Current programs	
Air and Missile Defense Radar (AMDR)	Sean D. Merrill, LeAnna M. Parkey
Airborne & Maritime/Fixed Station (AMF)	R. Eli DeVan
Amphibious Combat Vehicle (ACV)	Bonita J. P. Oden, Patrick R. Tierney
Armored Multi-Purpose Vehicle (AMPV)	Charlie Shivers, Marcus C. Ferguson, Andrea C. Evans
B-2 Defensive Management System Modernization (B-2 DMS-M)	Matthew B. Lea, Don M. Springman
CH-53K Heavy Lift Replacement Helicopter	Robert K. Miller, Victoria C. Klepacz
Combat Rescue Helicopter (CRH)	Sean C. Seales, Matthew T. Drerup
Common Infrared Countermeasure (CIRCM)	Danny G. Owens, Wendy P. Smythe
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	Jessica E. Karnis, Burns C. Eckert, Marcia Fernandez
DDG 51 Flight III Destroyer (DDG 51 Flight III)	Laura M. Jezewski, Karen L. Cassidy
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Ramzi N. Nemo, Angie Nichols-Friedman
Enhanced Polar System (EPS)	Andrew Redd, Bradley L. Terry
Evolved Expendable Launch Vehicle (EELV)	Erin E. Cohen, Andrew Redd
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Matthew T. Drerup, LeAnna M. Parkey
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	Nathaniel Vaught, Sean C. Seales
F-35 Lightning II Program (F-35 JSF)	Jillena S. Roberts, Megan L. Setser
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	Alexandra Dew Silva, Scott M. Purdy
Global Positioning System III (GPS III)	Jonathan Mulcare, Erin E. Cohen

Program name	Primary staff
Ground/Air Task Oriented Radar (G/ATOR)	Joe E. Hunter, Claire Li, Jonathan Munetz
Indirect Fire Protection Capability Increment 2 – Intercept, Block 1	Brian T. Smith
Integrated Air and Missile Defense (IAMD)	Julie C. Hadley, Meredith A. Kimmett
Joint Air-to-Ground Missile (JAGM)	Jessica M. Berkholtz, John W. Crawford
Joint Light Tactical Vehicle (JLTV)	Marcus C. Ferguson, Ethan I. Levy, Andrea C. Evans
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	Stephen V. Marchesani, Jennifer A. Dougherty
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	Scott M. Purdy, Jessica E. Karnis
KC-46A Tanker Modernization Program (KC-46A)	Katheryn S. Hubbell, Nathaniel Vaught
LHA 6 America Class Amphibious Assault Ship (LHA 6)	Alexis S. Olson, Mackenzie D. Verniero
Littoral Combat Ship (LCS)	Jacob L. Beier, Laurier R. Fish
Littoral Combat Ship - Mission Modules (LCS Packages)	Laurier R. Fish, Jacob L. Beier
M109A7 Family of Vehicles (M109A7 FOV)	Billy Allbritton, George A. Bustamante, Jr.
Military Global Positioning System User Equipment Increment 1 (MGUE Inc 1)	Claire Buck, Patrick Breiding
MQ-4C Triton Unmanned Aircraft System (MQ-4C)	Matthew M. Shaffer, Don M. Springman
MQ-8 Fire Scout Unmanned Aircraft System (MQ-8 Fire Scout)	James S. Kim, Justin M. Jaynes
Next Generation Jammer Increment 1 (NGJ Inc 1)	Laura T. Holliday, Daniel J. Glickstein
Next Generation Operational Control System (OCX)	Patrick Breiding, Claire Buck
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)	Thomas P. Twambly, Leslie C. Ashton
Columbia Class Ballistic Missile Submarine (SSBN) (formerly Ohio Replacement)	James Madar, Herbert J. Bowsher
P-8A Increment 3 Upgrade Program (P-8A Inc 3)	Heather B. Miller, Jocelyn C. Yin
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	Meredith Allen Kimmett, Brian T. Smith
Ship to Shore Connector Amphibious Craft (SSC)	Teague A. Lyons, Matthew M. Shaffer
Small Diameter Bomb Increment II (SDB II)	John W. Crawford, Jessica M. Berkholtz
Space Fence Ground Based Radar System Increment 1 (Space Fence Inc 1)	Laura D. Hook, Mary C. Diop
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)	Claire Li, Joe E. Hunter
VH-92A Presidential Helicopter (VH-92A)	Bonita J. P. Oden, Ramzi N. Nemo
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	Ryan Stott, Guisseli Reyes Turnell
Future Programs	
Advanced Pilot Trainer (APT)	Marvin E. Bonner, Meghan C. Perez
Amphibious Ship Replacement (LX(R))	Holly N. Williams
Improved Turbine Engine Program (ITEP)	Wendy P. Smythe, Danny G. Owens

Program name	Primary staff
Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)	J. Andrew Walker, Sameena Ismailjee
Long Range Precision Fires (LRPF)	George A. Bustamante, Jr., Billy Allbritton
MQ-25 Unmanned Aircraft System (MQ-25) (formerly UCLASS)	Robert P. Bullock, Julie C. Hadley
Frigate	Sean D. Merrill, LeAnna M. Parkey
Presidential Aircraft Recapitalization (PAR)	LeAnna M. Parkey, Wendell K. Hudson
John Lewis Class Fleet Replenishment Oiler (T-AO 205)(formerly T-AO(X))	Jocelyn C. Yin, Jenny Chow
Weather System Follow-on—Microwave (WSF-M)	Brenna Derritt, Maricela Cherveny

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