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Report to Congressional Committees

March 2016

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

Accessible Version

GAO-16-329SP

GAO Highlights

Highlights of GAO-16-329SP, a report to congressional committees

March 2016

DEFENSE ACQUISITIONS

Assessments of Selected Weapon Programs

Why GAO Did This Study

This is GAO's annual assessment of DOD major weapon system acquisitions, an area on GAO's high-risk list. DOD and Congress have taken meaningful steps to improve the acquisition of major weapon systems, yet programs continue to experience cost and schedule overruns. Further, GAO has emphasized the need to sustain the implementation of acquisition reforms and for programs to complete developmental testing before beginning production, thereby avoiding concurrency and its associated cost and schedule growth. With the continuing budgetary pressures, DOD cannot afford to miss opportunities to address inefficiencies in these programs to free up resources for higher priority needs.

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 2015 portfolio of 79 major defense acquisition programs; (2) the knowledge attained at key junctures in the acquisition process for 43 programs that were in development or early production; and (3) key acquisition reform initiatives and program concurrency. To develop the observations in this report, GAO analyzed cost, schedule, and quantity data from DOD's December 2014 Selected Acquisition Reports. GAO also collected data through two questionnaires to program offices on technology, design, and manufacturing knowledge; the use of knowledge-based acquisition practices; and the implementation of acquisition reforms and initiatives.

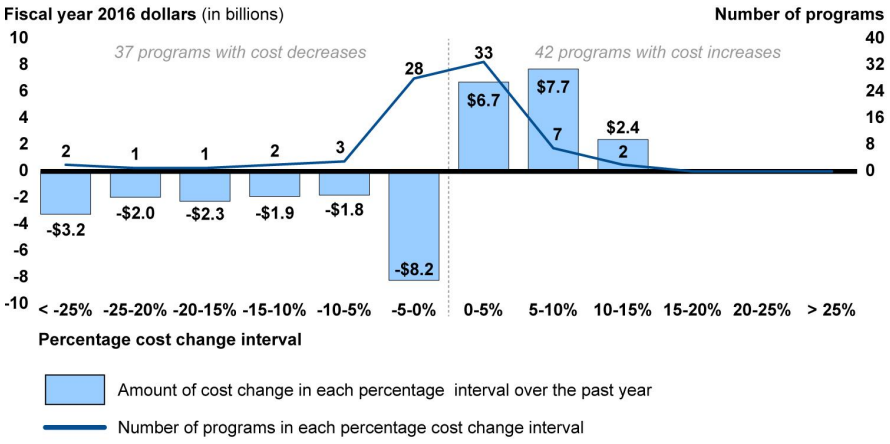
In commenting on a draft of this report DOD agreed with our findings and noted that our results appear to validate DOD's focus on continuous improvements.

View GAO-16-329SP. For more information, contact Michael J. Sullivan at (202) 512-4841 or sullivanm@gao.gov

What GAO Found

Over the past year, the number of programs in the Department of Defense's (DOD) portfolio of major defense acquisitions increased from 78 to 79, while DOD's total planned investment in these programs decreased from $1.45 trillion to $1.44 trillion. This estimate is in line with a trend seen since 2010 of decreases in the portfolio's total acquisition cost. The portfolio's cost growth since first full estimates has been substantial, but most of the cost growth occurred 5 or more years ago. The average time to deliver initial capability to the warfighter also increased by 2.4 months. This increase is due in part to the significant delays experienced by a few programs. In addition, while more programs in the 2015 portfolio reported cost increases than decreases the net change resulted in a decrease in the portfolio's total cost over the past year.

Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Most of the 43 programs GAO assessed this year are not yet fully following a knowledge-based acquisition approach, as GAO recommended. This held true for the 7 programs that recently entered system development as none completed all of our criteria for a best practices approach. Each of the 7 implemented some knowledge based practices—such as constraining the period for development—but 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.

Implementation of the reform initiatives GAO analyzed varies for the 43 programs assessed above as well as the 12 assessed that will become programs in the future. Programs are implementing acquisition reform initiatives—such as the use of affordability constraints and "should cost" analysis—and have realized $21 billion in savings as a result. However, there has been a decrease in the number of programs with acquisition strategies that include competition. In addition, a number of programs are concurrently conducting both software and hardware development during production, exposing programs to undue cost and schedule risk.

Contents

Foreward 1

Letter 4

Observations on the Cost and Schedule Performance of DOD's 2015 Major Defense Acquisition Program Portfolio 6
- Changes across Portfolios 8
- Changes in the 2015 portfolio 12
- Factors That Explain the Changes in the 2015 Portfolio 13
- Other Observations 22

Observations from Our Assessment of Knowledge Attained by Programs at Key Junctures 27
- Demonstrate Technology Maturity 33
- Complete Systems Engineering Reviews before Development Start 35
- Constrain System Development Phase to 6 years or Less 36
- Begin Future Programs with Adequate Knowledge 37
- Demonstrate Technology Maturity 40
- Demonstrate System Design Stability 41
- Prepare for Production 42
- Demonstrate Manufacturing Processes Are in Control 44
- Demonstrate Critical Processes on a Pilot Production Line 45
- Test a Production-Representative Prototype in Its Intended Environment 45

Observations about DOD's Implementation of Key Acquisition Reform Initiatives and Program Concurrency 46

Assessments of Individual Programs 56

Statement on Small Business Participation 61

Assessments of Individual Army programs 63
- Airborne and Maritime/Fixed Station (AMF) 64
- Armored Multi-Purpose Vehicle (AMPV) 65
- Common Infrared Countermeasure (CIRCM) 66
- Handheld, Manpack, and Small Form Fit Radios (HMS) 68
- Integrated Air and Missile Defense (IAMD) 70
- Joint Air-to-Ground Missile (JAGM) 72
- M109A7 Family of Vehicles (M109A7 FOV) 74
- Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE) 76

Warfighter Information Network-Tactical (WIN-T) Increment 2 78
Warfighter Information Network-Tactical (WIN-T) Increment 3 80
Indirect Fire Protection Capability Increment 2-Intercept Block 1 (IFPC Inc 2-I Block 1) 82
Improved Turbine Engine Program (ITEP) 83
Assessments of Individual Navy and Marine Corps programs 85
AIM-9X Block II Air-to-Air Missile (AIM-9X Block II) 87
Air and Missile Defense Radar (AMDR) 89
Amphibious Combat Vehicle (ACV) 91
CH-53K Heavy Lift Replacement Helicopter (CH-53K) 93
DDG 1000 Zumwalt Class Destroyer (DDG 1000) 95
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78) ... 97
Ground/Air Task Oriented Radar (G/ATOR) 99
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A) 101
LHA 6 America Class Amphibious Assault Ship (LHA 6). 103
Littoral Combat Ship (LCS) 105
Littoral Combat Ship - Mission Modules (LCS Packages) 107
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton) 109
MQ-8 (Fire Scout) 111
Next Generation Jammer Increment 1 (NGJ Increment 1) 113
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1) 115
Ship to Shore Connector Amphibious Craft (SSC) 117
VH-92A Presidential Helicopter Replacement Program (VH-92A) 119
Amphibious Ship Replacement (LX(R)) 121
DDG 51 Flight III Destroyer 122
Fleet Replenishment Oiler (T-AO(X)) 123
Ohio-Class Replacement (OR) 124
P-8A Increment 3 125
Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) System 126
Assessments of Individual Air Force programs 127
B-2 Defensive Management System Modernization (B-2 DMS-M) 129
Combat Rescue Helicopter (CRH) 131
Enhanced Polar System (EPS) 133

Evolved Expendable Launch Vehicle (EELV)..... 135
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod) 137
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)..... 139
Global Positioning System III (GPS III) 141
KC-46 Tanker Modernization Program (KC-46A)..... 143
Military GPS User Equipment (MGUE) Increment 1..... 145
Next Generation Operational Control System (GPS OCX) 147
Small Diameter Bomb Increment II (SDB II)..... 149
Space Fence Ground-Based Radar System Increment 1 (Space Fence Inc 1) 151
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)..... 153
Advanced Pilot Training (APT)..... 155
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)..... 156
Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap) 157
Presidential Aircraft Recapitalization (PAR) 158
Weather Satellite Follow-on (WSF)..... 159
Assessments of Individual Joint DOD-wide programs 161
F-35 Lightning II Program (F-35)..... 163
Joint Light Tactical Vehicle (JLTV)..... 165
Agency Comments and Our Evaluation 167

Appendix I: Scope and Methodology 169
Analysis of Acquisition Initiatives and Program Concurrency 174
Individual Assessments of Weapon Programs 176
Product Knowledge Data on Individual Two-Page Assessments..... 178

Appendix II: Current and First Full Estimates for DOD's 2015 Portfolio of Major Defense Acquisition Programs 182

Appendix III: Changes in DOD's 2015 Portfolio of Major Defense Acquisition Programs over Five Years and Since First Full Estimates 186

Appendix IV: Knowledge-Based Acquisition Practices 187

Appendix V: Technology Readiness Levels 189

Appendix VI: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System 191

Appendix VII: Comments from the Department of Defense 196

Appendix VIII: GAO Contact and Staff Acknowledgments 197

Appendix IX Accessible Data 200

Data Tables 200

Related GAO Products 205

Tables

Table 1: Cost Changes of DOD's Major Defense Acquisition Programs from 2014 to 2015 (Fiscal year 2016 dollars (in billions)) 8
Table 2: Changes in DOD's 2015 Portfolio of 79 Major Defense Acquisition Programs over the Past Year Fiscal year 2016 dollars (in billions) 12
Table 3: Programs with the Largest Total Acquisition Cost in the 2015 Portfolio 14
Table 4: Buying Power Analysis for the 2015 Portfolio 17
Table 5: Programs with the Largest Development Cost Percentage Increases over the Past Year 21
Table 6: Projected Implementation of Knowledge-Based Practices for Future Programs 37
Table 7: Current Cost Estimates and First Full Estimates for DOD's 2015 Portfolio of Major Defense Acquisition Programs 182
Table 8: Cost and Schedule Changes for Programs in DOD's 2015 Portfolio 186
Table 9: Best Practices for Knowledge-Based Acquisitions 187
Table 10: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System 192
Data Table for Highlights figure, Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio 200

Data Table for Figure 1: DOD Portfolio Cost and Size, 2005-2015 200
Data Table for Figure 2: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2005-2015 201
Data Table for Figure 3: Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio 201
Data Table for Figure 4: Distribution of the 1-year Change in Delivery of Initial Operational Capability within the 2015 Portfolio 202
Data Table for Figure 5: Comparison of the Cost Performance of DOD's 2011-2015 Portfolios 202
Data Table for Figure 6: Services' Percentage of the Portfolio's Total Acquisition Cost, 2005-2015 203
Data Table for Figure 11: Priorities for the $21.2 Billion in Total Realized "Should-Cost" Savings 203
Data Table for Figure 12: Current Programs' Plans to Promote Competition 204
Data Table for Figure 13: Future Programs' Plans to Promote Competition 204

Figures

Figure 1: DOD Portfolio Cost and Size, 2005-2015 9
Figure 2: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2005-2015 11
Figure 3: Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio 15
Figure 4: Distribution of the 1-year Change in Delivery of Initial Operational Capability within the 2015 Portfolio 20
Figure 5: Comparison of the Cost Performance of DOD's 2011-2015 Portfolios 24
Figure 6: Services' Percentage of the Portfolio's Total Acquisition Cost, 2005-2015 25
Figure 7: DOD's Acquisition Cycle and GAO Knowledge Points 28
Figure 8: Implementation of Knowledge-Based Practices for Programs at System Development Start 32
Figure 9: Implementation of Knowledge-Based Practices for Programs at Critical Design Review 40
Figure 10: Implementation of Knowledge-Based Practices for Programs at Production Decision 44

Figure 11: Priorities for the $21.2 Billion in Total Realized "Should-Cost" Savings 50
Figure 12: Current Programs' Plans to Promote Competition 52
Figure 13: Future Programs' Plans to Promote Competition 53
Figure 14: Illustration of Program Two-Page Assessment 58
Figure 15: Examples of Knowledge Scorecards 60

Abbreviations

ACV	Amphibious Combat Vehicle
APT	Advanced Pilot Training
AMDR	Air and Missile Defense Radar
B-2 DMS-M	B-2 Defensive Management System Modernization
BMDS	Ballistic Missile Defense System
CIRCM	Common Infrared Countermeasures
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
eSRS	Electronic Subcontracting Reporting System
F-15 EPAWSS	F-15 Eagle Passive/Active Warning and Survivability System
F-22 Inc 3.2 B	F-22 Increment 3.2 B Modernization
FAB-T	Family of Advanced Beyond Line-of-Sight Terminals
IFPC Inc 2	Indirect Fire Protection Capability Increment 2
ITEP	Improved Turbine Engine Program
JAGM	Joint Air-to-Ground Missile
JLTV	Joint Light Tactical Vehicle
JSTARS Recap	Joint Surveillance Target Attack Radar System Recapitalization
LX(R)	Amphibious Ship Replacement
MDAP	Major Defense Acquisition Program
MGUE	Military GPS User Equipment Increment 1
MRL	manufacturing readiness level
NA	not applicable
NGJ Inc 1	Next Generation Jammer Increment 1
OASuW Inc 1	Offensive Anti-Surface Warfare Increment 1
OR	Ohio-Class Replacement
OMB	Office of Management and Budget
P-8A Inc 3	P-8A Poseidon Increment 3
PAR	Presidential Aircraft Recapitalization
SAR	Selected Acquisition Report
SDB II	Small Diameter Bomb Increment II
Space Fence Inc 1	Space Fence Ground-Based Radar System Increment I
SSC	Ship to Shore Connector Amphibious Craft
T-AO(X)	Fleet Replenishment Oiler
TBD	to be determined
TRL	technology readiness level

UCLASS	Unmanned Carrier-Launched Airborne Surveillance and Strike system
WSARA	Weapon Systems Acquisition Reform Act
WSF	Weather Satellite Follow-On

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U.S. GOVERNMENT ACCOUNTABILITY OFFICE

Comptroller General
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March 31, 2016

Congressional Committees

I am pleased to present GAO's 14th annual assessment of the Department of Defense's (DOD) major defense acquisition programs. This report offers observations on the performance of DOD's current $1.4 trillion portfolio of 79 programs, the smallest portfolio in terms of total cost in a decade.[1] These 79 programs will require roughly a third of all DOD's development and procurement funding over the next 5 years. The level of investment these programs require makes it imperative that DOD continue its oversight of the implementation of key legislative and policy reforms it began in 2010 as well as the implementation of the best practices developed by GAO. In previous assessments, we reported that some of these reforms are addressing problems in DOD acquisitions. Our current assessment shows that these acquisition reforms and GAO's best practices are not uniformly implemented across the portfolio. As a result, some programs continue to realize significant cost growth and delays in delivering needed capability. Critically, new programs started each year fulfill only some of the best practices intended to achieve a level of knowledge that would demonstrate they are capable of meeting their performance requirements while meeting cost and schedule commitments. The highest point of leverage is at the start of a new program. Decision makers must ensure that new programs exhibit desirable principles before they are approved and funded.

Our current assessment shows that DOD is making progress in decreasing the amount of cost growth realized in the portfolio. When compared to the 78 major defense acquisition programs in last year's portfolio the current estimated cost of the 79 programs in the 2015 portfolio is nearly $15 billion less despite a net increase in programs. When assessing just the 79 programs in the 2015 portfolio costs have decreased by $2.5 billion over the past year, a net decrease largely attributable to quantity reductions in the Patriot Advanced Capability-3

[1]Our assessment of DOD's portfolio does not include the cost of the Ballistic Missile Defense System (BMDS), which we exclude as the program lacks an acquisition program baseline needed to support our assessment of cost and schedule change. For more information on BMDS, see GAO, *Missile Defense: Opportunities Exist to Reduce Acquisition Risk and Improve Reporting on System Capabilities,* GAO-15-345 (Washington, D.C.: May 6, 2015)

Missile Segment Enhancement program. In particular, 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 have achieved cost reductions or shown less cost growth than those that began development before 2010, indicating that recent reforms may be having a positive effect. This trend is continued when looking at the 2015 portfolio's $469 billion in cost growth since first full estimates as $373 billion of the growth occurred five or more years ago. Additionally, older programs in the portfolio carry a majority of this growth compared to newer programs.

However, our analysis also highlights areas that still need attention such as the use of knowledge-based best practices. For example, some programs are still carrying technology risk well into system development or are proceeding into production before manufacturing processes are under control. Not following knowledge-based best practices puts these programs at increased risk of unsatisfactory acquisition outcomes. Our assessment does show a similar number of programs are implementing initiatives focused on reducing cost through affordability constraints and efforts to find cost savings. In contrast, we also found less use of competition measures throughout the acquisition life cycle and overlap between developmental testing and production, which threaten programs' abilities to meet their cost, schedule, and performance objectives. In addition, we have a new observation on the defense industrial base showing that the companies developing and delivering the largest DOD programs are performing well in the market. We plan to have more analysis in this area in our next assessment.

Weapon system acquisitions remain an area on GAO's high-risk list.[2] Continued efforts by DOD to mitigate these risks through adherence to best practices and effective program management are essential.

[2]GAO, High-Risk Series: An Update, GAO-15-290 (Washington, D.C.: February 11, 2015).

Gene L. Dodaro
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March 31, 2016

Congressional Committees

The joint explanatory statement to the Department of Defense Appropriations Act, 2009, included a provision for GAO to annually review the department's $1.4 trillion portfolio of major weapon programs.[3] 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.[4] Additionally, this report's assessment of the Amphibious Combat Vehicle (ACV) along with GAO's October 2015 report on the ACV program constitute GAO's response to the annual reporting requirement for 2016 required by the National Defense Authorization Act for Fiscal Year 2014.[5]

This report includes observations on (1) the cost and schedule performance of DOD's 2015 portfolio of 79 major defense acquisition programs, (2) the knowledge attained at key junctures in the acquisition process for 55 current and future weapon programs in development or

[3]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).

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

[5]GAO, *Amphibious Combat Vehicle: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined*, GAO-16-22 (Washington, D.C.: Oct. 28, 2015). The National Defense Authorization Act for Fiscal Year 2014, Pub. L. No.113-66, § 251 (2013).

early production, and (3) key acquisition reform initiatives and whether programs are conducting or planning concurrent testing and production.[6]

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

- We assessed 79 major defense acquisition programs in DOD's 2015 portfolio for our analysis of cost and schedule performance. We obtained cost, schedule, and quantity data from DOD's December 2014 Selected Acquisition Reports (SAR) and from the Defense Acquisition Management Information Retrieval Purview (DAMIR) system. We assessed the reliability of the data by interviewing knowledgeable agency officials on the steps they take to ensure data reliability, and determined that the data were sufficiently reliable for the purposes of this report.
- We assessed 43 major defense acquisition programs currently between the start of development and the early stages of production for knowledge attained at key junctures and their implementation of acquisition reforms. We obtained information on the extent to which the programs follow knowledge-based practices—established by the oeuvre 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 reviews, design drawings, manufacturing planning and execution, and the implementation of specific acquisition reforms. The other was a data-collection instrument used to collect schedule dates, the programs' critical technology levels, and other information. We received questionnaire responses from all 43 current programs from August through October 2015.
- We also assessed 12 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 their plans for

[6]Major defense acquisition programs (MDAP) are those identified by DOD 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 major defense acquisition programs throughout this report.

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 12 future programs from July through August 2015.

We present individual assessments of 55 programs—43 current and 12 future weapon programs. These assessments include major defense acquisition programs currently in development or early production as well as future programs. Appendix I contains detailed information on our scope and methodology.

We conducted this performance audit from June 2015 to March 2016 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 based on our audit objectives.

Observations on the Cost and Schedule Performance of DOD's 2015 Major Defense Acquisition Program Portfolio

Since 2014, the number of programs in DOD's portfolio of major defense acquisitions increased from 78 to 79, and DOD's total planned investment in these programs decreased by nearly $15 billion from $1.45 trillion to $1.44 trillion. This estimate is in line with a trend seen since 2010 of decreases in the portfolio's total acquisition cost. The programs in the 2015 portfolio reported an increase in the average schedule delay in achieving initial capability of 2.4 months over the past year. The total amount of funding needed to complete the 2015 portfolio is estimated at $603 billion, which is a decrease from the 2014 portfolio and is the lowest amount in over a decade. Of the $603 billion, $571 billion is planned for procurement and $32 billion is planned for development. We also found that more programs reported gains in buying power when compared to programs in the previous portfolio. Despite the portfolio's overall cost decrease, 42 of 79 programs increased in cost over the past year and the entire portfolio experienced $469 billion in cost growth since programs established their first full estimates, primarily due to cost growth that occurred 5 or more years ago.

Our analysis of DOD's 2015 portfolio allows us to make the following 11 observations.

Cost and Schedule Performance Observations

Changes across portfolios

1. When compared to the 2014 portfolio, the cost of the 2015 portfolio decreased by nearly $15 billion from $1,455 to $1,440 billion and the number of programs in the portfolio increased by one to 79.[a]
2. The total amount of funding required for the portfolio has been decreasing since 2010.[b] The amount of future funding needed to complete the portfolio—$603 billion—is at its lowest point in over a decade. Of the $603 billion of future funding, $571 billion is for procurement and $32 billion is for development. The low amount of future development funding required is likely due to a number of factors, including newer programs with less risk entering system development.

Changes in the 2015 portfolio

3. The cost estimates over the past year for the 79 programs in the 2015 portfolio decreased by $2.5 billion and the average schedule delay in achieving initial capability increased by 2.4 months. When assessed against first full estimates, total costs have increased by $469 billion, over 48 percent, most of which occurred over 5 years ago. The average delay in delivering initial capabilities has increased to almost 30 months.

Factors that explain changes in the 2015 portfolio

4. Older programs in the portfolio carry a majority of the total cost and cost growth since first full estimates when compared to newer programs. Of the 79 programs in the 2015 portfolio, 40 were also in the 2005 portfolio and represent 80 percent of the portfolio's total acquisition cost—over $1.1 trillion of the $1.4 trillion total.
5. While the total cost of the 2015 portfolio decreased, 42 of the 79 programs increased in cost over the past year. Cost estimate decreases on 37 programs resulted in the overall net cost decrease.
6. Thirty-eight programs in the portfolio gained buying power during the past year resulting in a net gain of $10.7 billion. Six programs in our analysis have demonstrated buying power gains or losses on an annual basis over the past 5 years.
7. Schedule delays over the past year in 11 of the 79 programs contributed to the portfolio's overall delay of 2.4 months. The Airborne Maritime/Fixed Station radio system experienced the largest delay at more than 8 years, which disproportionately affected the portfolio.
8. Over the past year, 16 programs reported development cost growth while in production, a phase of the acquisition cycle that should have minimal development cost growth. This represents concurrency, albeit for different reasons, and is a contributor to cost growth.

Other Observations

9. As measured against the metrics discussed with the Office of Management and Budget (OMB) and DOD, more programs meet each metric for cost change than our last assessment. Most notably, 72 percent of programs meet the threshold for less than 10 percent growth over the past 5 years. Seventy-six percent meet the threshold for less than 2 percent growth in the past year. Forty-seven percent meet the threshold for less than 15 percent cost growth since first full estimates.
10. Army programs' percentage of the total cost of the portfolio is the smallest of the services and has been decreasing since 2007. The Navy and Air Force programs' percentages have been increasing since 2007 and 2012 respectively. Navy programs account for almost 55 percent of the 2015 portfolio's total estimated acquisition cost.
11. The equity prices of contractors delivering the 10 costliest programs have performed well relative to broad-based market indices, indicating that investors expect these firms to remain profitable well into the future.

[a]All dollar figures are in fiscal year 2016 constant dollars, unless otherwise noted.

[b]Details on program costs used for this analysis are provided in appendix I.

Changes across Portfolios

1. **When compared to the 2014 portfolio, the cost of the 2015 portfolio decreased by nearly $15 billion—from $1,455 to $1,440 billion—and the number of programs in the portfolio increased by one to 79.** The decrease in cost is due primarily to the five programs that exited the portfolio and accounted for $39 billion in spending. Three of these 5 programs completed their planned development and procurement—the MH-60S Fleet Combat Support Helicopter, the National Airspace System, and the Patriot Advanced Capability program—and accounted for over $24 billion in cost. The termination of the Patriot/Medium Extended Air Defense System Combined Aggregate Program and restructuring of the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System accounted for $14.5 billion of the remaining $39 billion. The 6 programs entering the portfolio have a total estimated cost of $24 billion. The changes from the 2014 portfolio to the 2015 portfolio are outlined in table 1 below.

Table 1: Cost Changes of DOD's Major Defense Acquisition Programs from 2014 to 2015 (Fiscal year 2016 dollars (in billions))

Areas	FY 2015 dollars
2014 portfolio (78 programs)	**$1,455**
Less estimated total cost of the 5 exiting programs	-$39
Plus estimated total cost of the 6 entering programs	+$24
Less net cost changes on the 73 remaining programs	-$1
2015 portfolio (79 programs)	**$1,440**

Source: GAO analysis of DOD data. | GAO-16-329SP

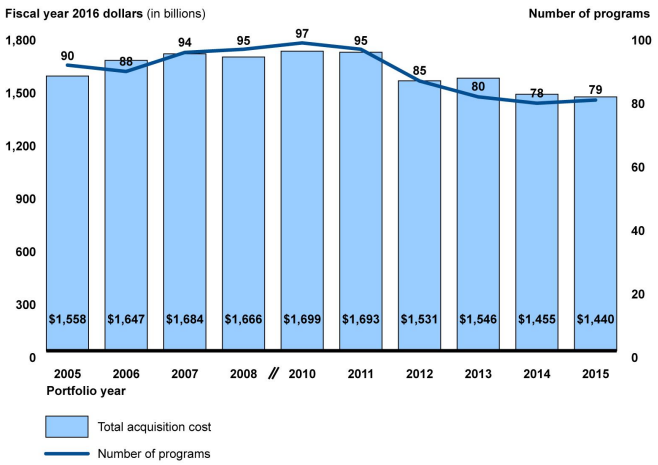
Note: Our assessment of DOD's 2014 and 2015 portfolios does not include the cost of the Ballistic Missile Defense System (BMDS), which we exclude as the program lacks an acquisition program baseline needed to support our assessment of cost and schedule change. Some numbers may not sum due to rounding.

Six programs began system development and entered the portfolio, the Combat Rescue Helicopter, Enhanced Polar System, Intercontinental Ballistic Missile Fuze Modernization, Patriot Advanced Capability-3 Missile Segment Enhancement, Space Fence Ground-Based Radar System Increment 1, and the VH-92A Presidential Helicopter. The Patriot Advanced Capability-3 Missile Segment Enhancement is leveraging the resources and development conducted by the Patriot/Medium Extended Air Defense System Combined Aggregate Program's Missile Unit sub-element. Two programs—the Combat Rescue Helicopter and the VH-92A

Presidential Helicopter—come from previously canceled acquisition programs. The remaining three programs were in technology development before their entry into the portfolio was approved.

2. **The total cost of the portfolio has been decreasing since 2010. The amount of future funding needed to complete the portfolio—$603 billion—is at its lowest point in over a decade. Of the $603 billion of future funding, $571 billion is for procurement and only $32 billion is for development. The low level of remaining development funding is likely due to many factors, including newer programs with less risk entering system development.** The cost and number of programs in the portfolio has decreased over the past 5 years as more programs have exited than entered, the programs entering are less costly, and ongoing programs are realizing cost savings. Currently, the total acquisition cost of the portfolio is estimated at $1.4 trillion, including $603 billion for future funding. Programs started in the past 5 years account for just 15 percent of that $603 billion. Figure 1 shows the changes in total cost and number of programs within DOD's portfolio of major weapon acquisitions since 2005.

Figure 1: DOD Portfolio Cost and Size, 2005-2015



Source: GAO analysis of DOD data. | GAO-16-329SP

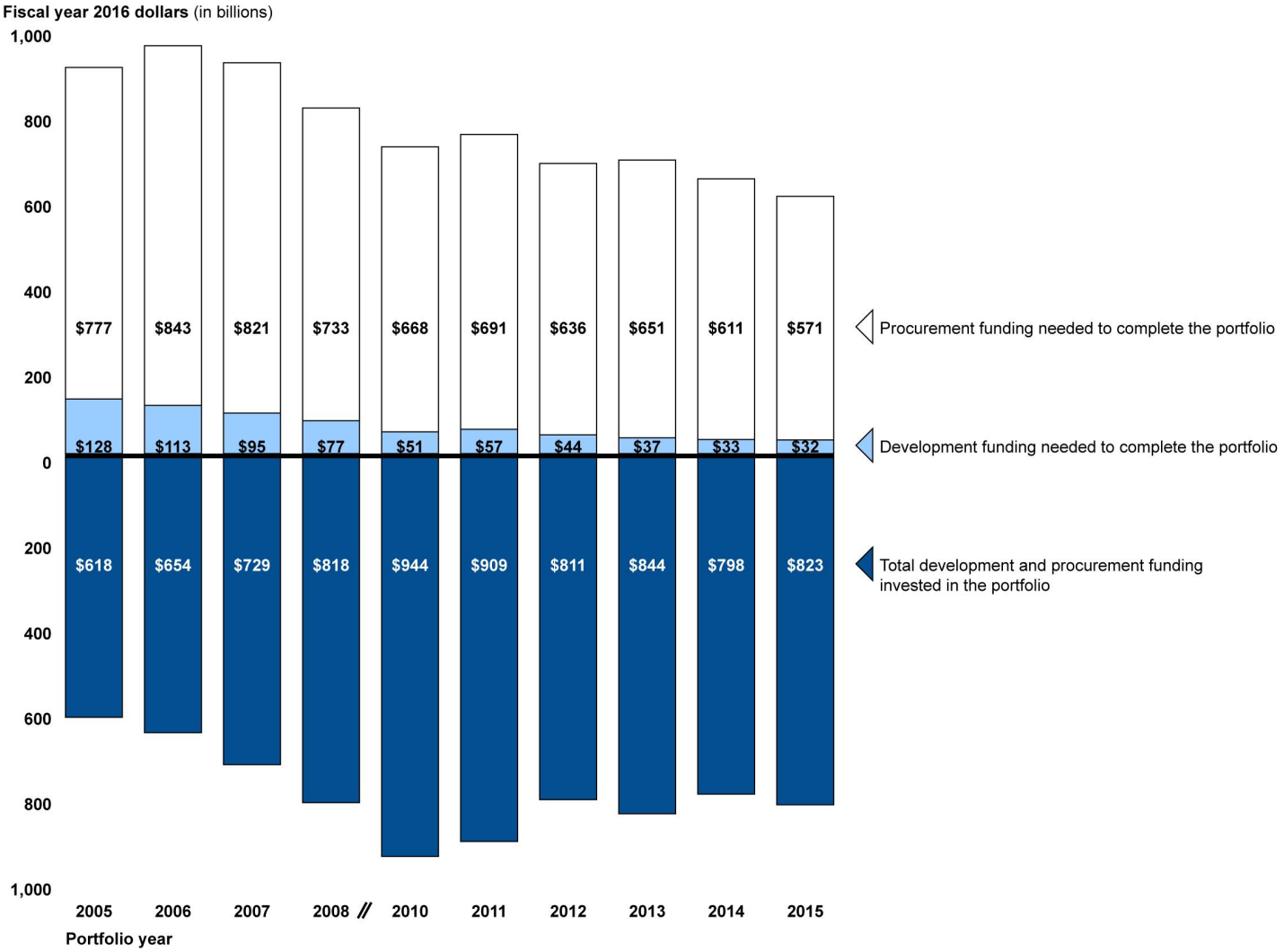
Note: The 2009 portfolio is excluded because there were no annual Selected Acquisition Reports (SAR) released for the December 2008 submission date.

The amount of development and procurement funding needed to complete the 2015 portfolio, $571 billion in procurement and $32

billion for development, has been generally decreasing.[7] By contrast, in 2005 future funding was over $904 billion, or 58 percent, of the portfolio's total cost. Figure 2 shows the change in the portfolio's future funding needs and funding invested as a share of the portfolio's total acquisition cost since 2005.

[7]Other costs include military construction and operations and maintenance, which account for $13.1 billion of the 2015 portfolio's total acquisition cost.

Figure 2: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2005-2015



Source: GAO analysis of DOD data. | GAO-16-329SP

Note: The 2009 portfolio is excluded because there were no annual Selected Acquisition Reports released in December 2008.

The estimated cost to complete the research and development associated with the portfolio is at the lowest point in a decade, approximately $32 billion. Several factors may have contributed to this low level of future development funds, such as

- declining budgets;

- newer programs based on more reasonable requirements that leverage mature technologies or modify existing designs;
- a majority of programs are in early or full production—a phase in the acquisition life cycle that should require less development funding; and
- several programs starting system development over the past two years have chosen potentially less-risky or less complex acquisition approaches, such as acquiring capability in increments and trading capability for affordability.

Changes in the 2015 portfolio

3. **Over the past year, the total acquisition cost for the 79 programs in the 2015 portfolio decreased by $2.5 billion and the average schedule delay in achieving initial capability increased by 2.4 months. When assessed against first full estimates, total costs have increased by $469 billion, over 48 percent, most of which occurred over 5 years ago. The average delay in delivering initial capabilities has increased to almost 30 months.** While the first observation discusses the change from the prior portfolio of 78 programs to the current portfolio of 79 programs, this observation addresses the change that occurred on the 79 programs in the current portfolio. Table 2 shows the change in cost and schedule for the 2015 portfolio in the past year.

Table 2: Changes in DOD's 2015 Portfolio of 79 Major Defense Acquisition Programs over the Past Year Fiscal year 2016 dollars (in billions)

	Estimated portfolio cost in 2014	Estimated portfolio cost in 2015	Estimated portfolio change since 2014	Percentage change since 2014
Total estimated research and development cost	**$285.9**	**$289.0**	**$3.1**	**1.1%**
Total estimated procurement cost	**1,143.5**	**1,137.6**	**-6.0**	**-0.5**
Total estimated acquisition cost[a]	**1,442.0**	**1,439.6**	**-2.5**	**-0.2**
Average delay in delivering initial capabilities from the first full estimate of cost and schedule	27 months	29.5 months	2.4 months additional delay	1.3

Source: GAO analysis of DOD data. | GAO-16-329SP

[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. Some numbers may not sum due to rounding.

The current portfolio's total acquisition cost has decreased over the past year by $2.5 billion, due primarily to a $6.0 billion decrease in procurement costs which offset a $3.1 billion increase in development costs. The Patriot Advanced Capability-3 Missile Segment

Enhancement program accounts for $2 billion of the $2.5 billion decrease due to a quantity reduction of 28.5 percent.

When measuring the current portfolio's schedule performance over the past year, we found that the delay in delivery of initial operating capability grew almost two and a half months over the past year and now stands at 29.5 months from initial estimates.[8]

When assessed against first full estimates, the total cost of the 2015 portfolio increased by nearly $469 billion, or 48 percent, most of which occurred more than 5 years ago.[9] These cost estimates and percent growth are consistent with what we reported in our prior assessment.

Factors That Explain the Changes in the 2015 Portfolio

4. **Older programs in the portfolio carry a majority of the total cost and cost growth since first full estimates compared to newer programs. Of the 79 programs in the 2015 portfolio, 40 were also in the 2005 portfolio and represent 80 percent of the portfolio's total acquisition cost—over $1.1 trillion of the $1.4 trillion total.** The 40 programs common to the 2005 and 2015 portfolios range in age between 11 and 38 years. These programs account for 80 percent of the current portfolio's $1.4 trillion in total acquisition cost. Consequently, the 40 newer programs account for just 20 percent of the total portfolio acquisition cost.

   The total acquisition cost of the portfolio is also driven in large part by the 10 costliest programs, which currently account for $866 billion, or 60 percent of the portfolio's total cost. Nine of the 10 costliest programs in the 2015 portfolio were also in the 2005 portfolio. These programs are over 11 years old and account for 65 percent of the portfolio's cost growth since first full estimates as shown in table 3 below.

[8]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.

[9]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.

Table 3: Programs with the Largest Total Acquisition Cost in the 2015 Portfolio
Fiscal year 2016 dollars (in billions)

Program	Years since first full estimate	Total acquisition cost	Total acquisition cost growth since initial estimates
F-35 Joint Strike Fighter	14	$340	$111
DDG 51 Arleigh Burke Class Guided Missile Destroyer	33	115	99
SSN 774 Virginia Class Submarine	21	91	26
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft	33	62	19
Evolved Expendable Launch Vehicle	19	61	42
Trident II Missile	38	58	2
KC-46 Tanker Modernization Program	4.9	44	-4
Gerald R. Ford Class Nuclear Aircraft Carrier	11.7	36	-2
P-8A Poseidon Multi-Mission Maritime Aircraft	15.8	33	.03
UH-60M Black Hawk Helicopter	14.7	26	12
Ten costliest programs		**$866**	**$306**
Remaining portfolio total		**$574**	**$163**
2015 portfolio total		**$1,440**	**$469**

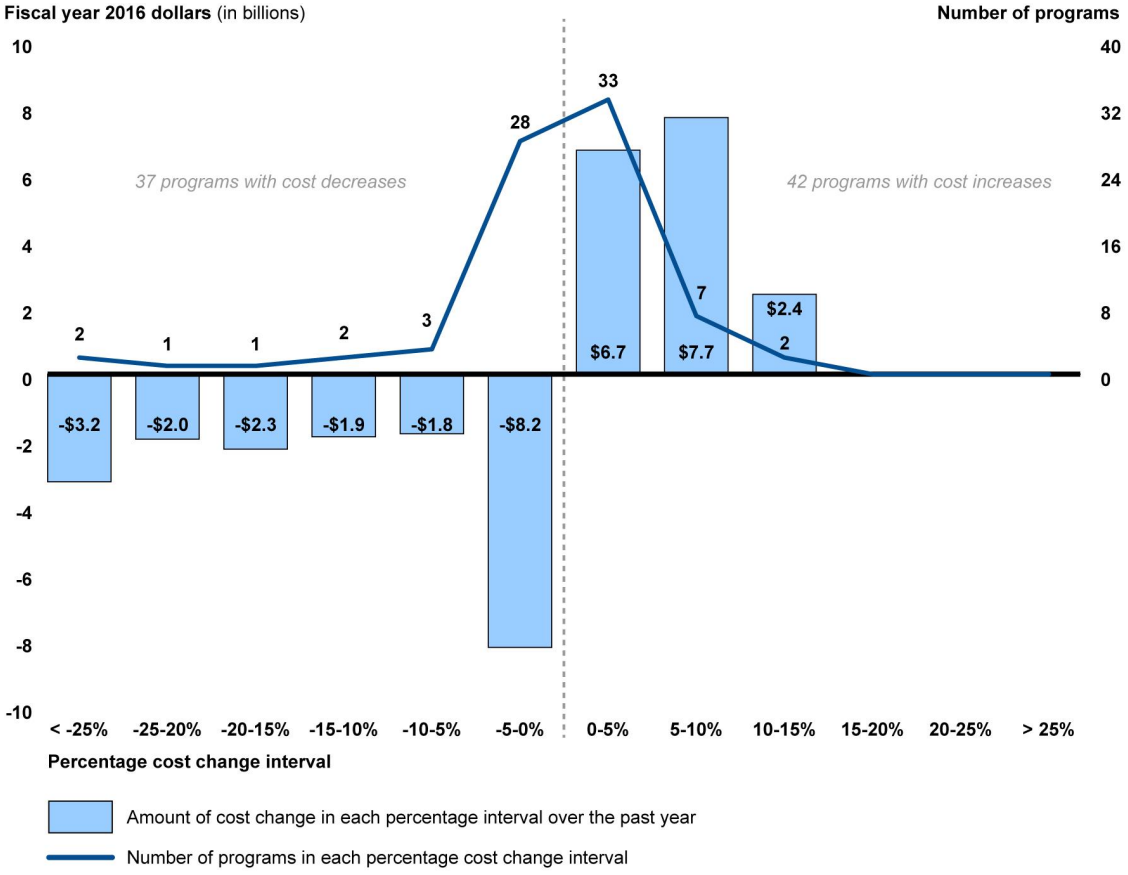
Source: GAO analysis of DOD data. | GAO-16-329SP

Eighty percent of the 2015 portfolio's cost growth since first full estimates—$373 billion—occurred five or more years ago. Since 2010, the current portfolio has accumulated $95.7 billion in cost growth, about 20 percent of the $469 billion total. That same year, DOD began implementation of WSARA and its "Better Buying Power" initiatives.[10] In addition, our analysis also shows that programs started since WSARA and the "Better Buying Power" initiatives have realized cost decreases from their first full estimates. The 14 programs that began system development since 2010 have collectively reduced their total estimated acquisition costs by over $580 million since their first full estimates. However, these programs have only recently begun development and may encounter issues in the future. DOD and Congress will need to continue oversight to ensure they do not increase in cost.

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

5. **Of the 79 programs, 37 saw $19.3 billion in cost decreases while 42 programs experienced $16.8 billion in cost increases resulting in a net decrease in the total acquisition cost of nearly $2.5 billion.** The $2.5 billion decrease shown in table 2 above is the net result of cost changes on all 79 programs in the current portfolio. The distribution of those cost changes across the entire portfolio is shown below in figure 3.

Figure 3: Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Of the 37 programs that decreased their total acquisition cost over the past year,

- 29 did so by finding efficiencies in the program and not by changing procurement quantities resulting in total cost decreases of $9.5 billion;
- 6 reduced their planned procurement quantities thereby reducing overall cost by $8.1 billion; and
- 2 programs—the Evolved Expendable Launch Vehicle and the Ship-to-Shore Connector Amphibious Craft—were able to reduce their overall cost by $1.7 billion while increasing their planned procurement quantities.

In contrast, 42 programs reported total acquisition cost increases over the past year. Of these,

- 27 reported cost increases due to inefficiencies in the program rather than a change in procurement quantities resulting in a total cost increase of almost $2.9 billion;
- 15 increased their planned procurement quantities resulting in a cost increase of almost $14 billion.

6. **Thirty-eight programs in the portfolio gained buying power during the past year resulting in a gain of $10.7 billion. There are a few programs that gain or lose buying power year after year; 6 programs in our analysis report such gains or losses.** As can be seen from the preceding discussion of individual cost increases and decreases, to better 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.

   According to our calculation of cost changes attributable to quantity changes we would have expected the portfolio to increase by $4.7 billion in procurement costs. Instead, procurement costs for the portfolio have decreased by $6 billion over the past year, indicating that programs found efficiencies in other areas to offset the cost of

additional quantities and the portfolio overall realized a buying power gain.[11] Our calculation of how programs' cost and quantity changes affected their buying power is presented in table 4.

Table 4: Buying Power Analysis for the 2015 Portfolio
Fiscal year 2016 dollars (in billions)

	Number of programs	GAO-calculated cost change attributable to quantity changes	Actual procurement cost change	GAO calculated cost change not attributable to quantity changes
Programs that gained buying power	38	$10.6	-$5.4	-$16.0
Procurement cost decreased with no quantity change	26	$0.0	-$10.6	-$10.6
Quantity increased with less cost increase than anticipated	11	$10.6	$5.9	-$4.7
Quantity decreased with more cost decrease than anticipated	1	-$.06	-$0.7	-$0.7
Programs that lost buying power	**35**	**-$4.2**	**$1.1**	**$5.3**
Procurement cost increased with no quantity change	25	$0.0	$2.0	$2.0
Quantity increased with more cost increase than anticipated	6	$4.9	$5.5	$0.6
Quantity decreased with less cost decrease than anticipated	4	-$9.1	-$6.3	$2.8
Programs with no change in buying power	5	$0.0	$0.0	$0.0
Program eliminated procurement	**1**	**-$1.7**	**-$1.7**	**$0.0**
Portfolio totals	**79**	**$4.7**	**-$6.0**	**-$10.7**

Source: GAO analysis of DOD data. | GAO-16-329SP

Note: Some numbers may not sum due to rounding.

Our analysis shows that 38 programs increased their buying power in the past year and reduced procurement costs by a total of $5.4 billion. This total is the net amount of cost change given increases and decreases due to other program efficiencies. Twenty-six of these 38 programs decreased procurement costs with no change in their procurement quantity indicating that they found efficiencies elsewhere. 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.

Eleven programs are buying additional quantities at lower prices. In other words, their planned procurement quantities increased but the corresponding procurement cost did not increase in kind or was offset

[11]A description of the calculation used can be found in appendix I.

by other efficiencies. For example, the SSN 774 Virginia Class Submarine procured two additional submarines with a lower than expected procurement cost increase. Our analysis indicates that if only the quantity increase is considered, the program's procurement costs should have risen by $5.2 billion. Instead, the program realized a buying power gain, due to program cost efficiencies and realized reductions of $390 million.

Thirty-five programs lost buying power in the past year with actual procurement cost increases of $1.1 billion. By our calculations, the net result of quantity changes on these programs should have resulted in a $4.2 billion cost decrease due to reductions in quantities on 4 of these 35 programs. This means that procurement cost increases not related to quantity changes generated $5.3 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 CH-47F Improved Cargo Helicopter program lost buying power as it experienced a procurement cost increase of $39 million over the past year with no change in its planned procurement quantity. Six other programs increased their planned procurement quantities but incurred a higher than expected procurement cost increase, indicating that they lost efficiencies elsewhere. The remaining 4 programs reported decreases in their initial quantities; however, the cost reductions on these programs are less than expected by our calculations.

In addition, there are a handful of individual programs that gain or lose buying power consistently:

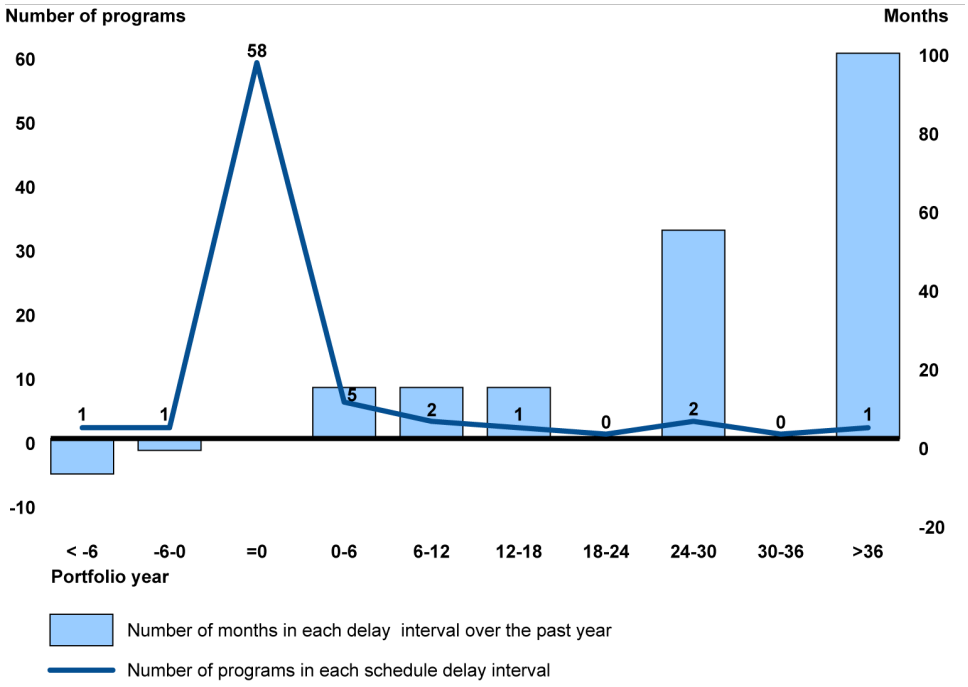
- Three programs—Tactical Tomahawk, MQ-4C Triton Unmanned Aircraft System, and C-5 Reliability Enhancement and Re-engineering Program—experienced gains in buying power each year over the past 5 years. Tactical Tomahawk changed its quantities in 3 of the past 5 years but quantities for the other programs did not change.
- Three programs—CH-53K Heavy Lift Replacement Helicopter, DDG 1000 Zumwalt Class Destroyer, and Joint Precision Approach and Landing System—lost buying power in each of the past 5 years. These programs generally had successive years of procurement cost increases with only minimal quantity changes that were outweighed by other inefficiencies.

Of the programs that have consistently lost buying power over the past 5 years, most have also had schedule delays longer than those that gained buying power consistently.

7. **Schedule delays over the past year in 11 of the 79 programs contributed to the portfolio's overall delay of 2.4 months. The Airborne Maritime/Fixed Station radio system experienced the largest delay at more than 8 years, which disproportionately affected the portfolio.** Thirteen programs in the current portfolio reported a schedule change over the past year, 11 of which were delays. The average 2.4 month schedule increase for 2015 is the result of changes reported by all the programs in the current portfolio. If the effect of the Airborne Maritime/Fixed Station radio system's delay is removed from the analysis, the average schedule increase for 2015 is 1.1 months, similar to what we reported in our last assessment.[12] Figure 4 below shows the schedule changes over the past year.

[12]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-15-342SP (Washington, D.C.: Mar. 12, 2015).

Figure 4: Distribution of the 1-year Change in Delivery of Initial Operational Capability within the 2015 Portfolio



Source: GAO analysis of DOD data. | GAO-16-329SP

Six programs reported schedule delays of more than 6 months over the past year. For example, due to an overall Joint Tactical Radio System reorganization, the Airborne Maritime/Fixed Station radio system was restructured in 2012. The program had not been reporting an initial operational capability delivery date until this past year when it reported a delay of 98 months, more than 8 years, from its initial estimate. In another case, the Next Generation Operational Control System reported a delay of 27 months over the past year. Due to issues with the integration and testing of its initial block of capability and the concurrent systems engineering approach for subsequent blocks, the program reported delays to its delivery of initial capability and its production decision dates. Similarly, the DDG 1000 Zumwalt Class Destroyer reported a delay of 26 months over the past year due to technical risk, shipyard performance, and shipyard workforce constraints. Another 5 of the 11 programs reported schedule delays of less than six months over the past year.

Two programs—the B-2 Extremely High Frequency Satellite Communications and Computer Increment 1 and Space Fence Ground-Based Radar System Increment 1—reported dates for

delivery of initial operational capability 3 and 9 months earlier than expected. The B-2 Extremely High Frequency Satellite Communications and Computer Increment 1 date was revised to reflect the actual delivery of capability and the Space Fence program's change is the result of a schedule revision post-contract award.

8. **Sixteen programs in production reported development cost growth over the past year even though production is a phase of the acquisition cycle which should have minimal development cost growth. This represents concurrency, albeit for differing reasons, and is a contributor to cost growth.** The 16 programs in our assessment that report development cost increases of 2 percent or more over the past year account for $3.3 billion in development cost growth. These programs are in production, a phase of the acquisition cycle which should have minimal development cost growth. On average, these 16 programs have been in the portfolio more than 16 years and 56 percent of them have already achieved their initial operating capability. Table 5 shows the extent and causes of the development cost growth on these programs.

Table 5: Programs with the Largest Development Cost Percentage Increases over the Past Year
Fiscal year 2016 dollars (in millions)

Program	Percentage increase in development cost over the past year	Amount of development cost growth over the past year	Initial capability achieved	Primary cause for development cost increase
AIM-9X Block II Air-to-Air Missile	45%	$172	No	Deficiency
MQ-8 Fire Scout	36	325	Yes	Unplanned capability
Evolved Expendable Launch Vehicle	21	528	Yes	Unplanned capability
Navy Multiband Terminal	18	135	Yes	Unplanned capability
Patriot Advanced Capability-3 Missile Segment Enhancement	9	80	No	Unplanned capability
Family of Advanced Beyond-Line-of-Sight Terminals	9	215	No	Deficiency
DDG 51Arleigh Burke Class Guided Missile Destroyer	6	364	Yes	Unplanned capability
Global Positioning System III	6	180	NA	Deficiency
Next Generation Operational Control System	5	190	No	Deficiency
LHA 6 America Class Amphibious Assault Ship	4	17	No	Unplanned capability
Littoral Combat Ship Mission Packages	4	93	No	Deficiency
EA-18G Growler Aircraft	4	85	Yes	Unplanned capability
AIM-120 Advanced Medium Range Air-to-Air Missile	4	157	Yes	Unplanned capability
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft	3	484	Yes	Unplanned capability

Program	Percentage increase in development cost over the past year	Amount of development cost growth over the past year	Initial capability achieved	Primary cause for development cost increase
Multifunctional Information Distribution System	3	69	Yes	Unplanned capability
Cooperative Engagement Capability	3	109	Yes	Unplanned capability

Source: GAO analysis of DOD data. | GAO-16-329SP

Development cost increases on these programs are generally due to one of two factors:

- Five of the 16 needed additional funding to correct for deficiencies found in testing. For example, the AIM-9X Block II program reported a development cost increase of 45 percent due to deficiencies found during operational testing.
- Eleven of the 16 added unplanned capability to a program's baseline. Increasing the capabilities of a program beyond the established requirements adds cost and potential risk to mature weapon systems already in production. Three of the four largest development percentage increases are due to increases in capability. Adding capability while in production leads to concurrency in development and production and can lead to instability. In some cases the added capability may be warranted whereas in others it might be best to develop and deliver a new capability incrementally, which could be part of a new major defense acquisition program, rather than as an add-in to a current program, as recommended by best practices for cost estimating.[13] Adding capability to existing cost baselines can also create oversight challenges as it becomes difficult to differentiate the reasons for cost growth.

Other Observations

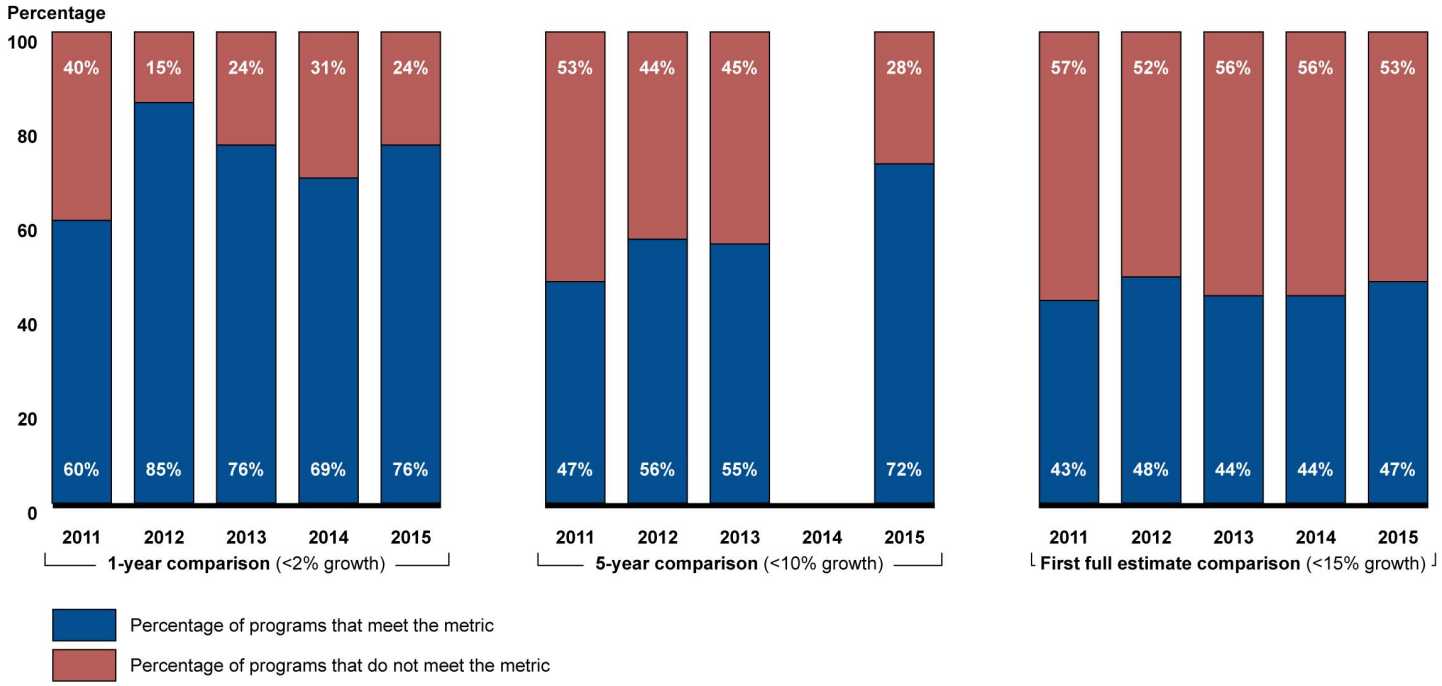
9. As measured against the metrics discussed with the Office of Management and Budget (OMB) and DOD, more programs meet each metric for cost change than previous assessments. Most notably, 72 percent of programs meet the threshold for less than 10 percent growth over the past 5 years compared to the 2013

[13]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, GAO-09-3SP (Washington, D.C.: Mar. 2, 2009).

portfolio in which 55 percent of programs met this metric. Seventy-six percent meet the threshold for less than 2 percent growth in the past year. Forty-seven percent meet the threshold for less than 15 percent cost growth since first full estimates. In December 2008, GAO, OMB, and DOD discussed 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.[14] We have reported on these outcomes since 2012 and figure 5 shows how the performance of the current portfolio compares to our prior assessments.

[14]DOD no longer supports the use of these metrics. We continue to believe that they have value.

Figure 5: Comparison of the Cost Performance of DOD's 2011-2015 Portfolios



Source: GAO analysis of DOD data. | GAO-16-329SP

Note: For the 2014 Portfolio we did not calculate a 5-year comparison as there were no December 2008 SARs issued.

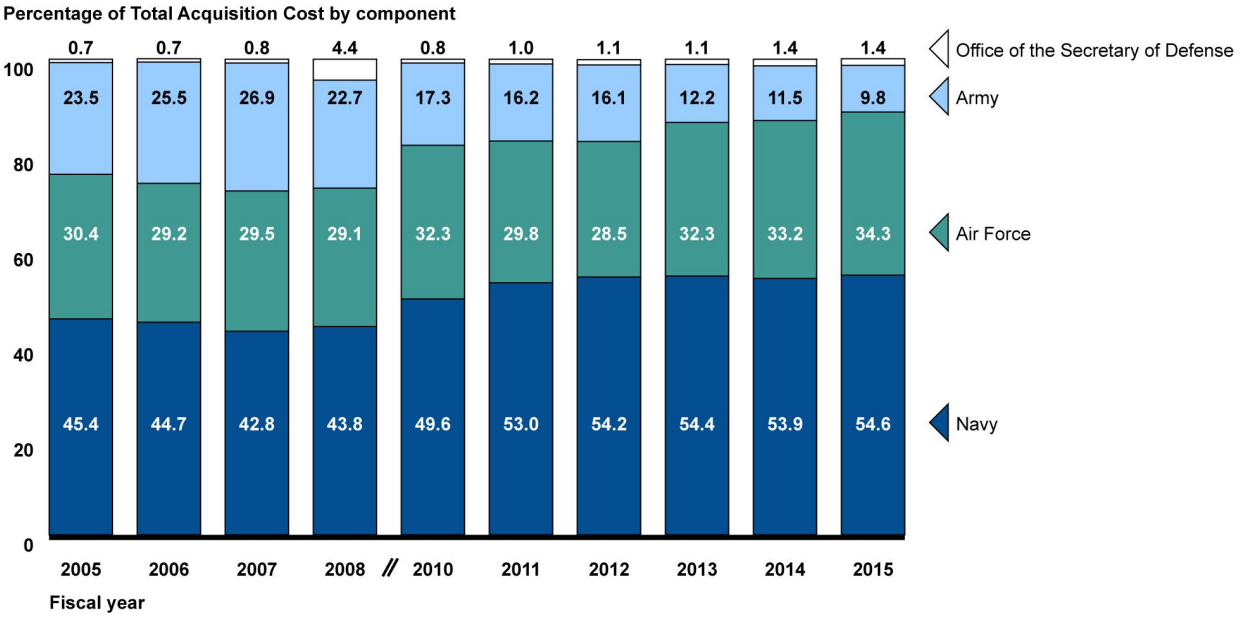
Seventy-two percent of programs in the current portfolio kept their cost growth under 10 percent over the past 5 years. This is a significant improvement compared to the 2013 portfolio, the last time we assessed this metric. As this metric measures programs' cost growth over the past 5 years, the improvement in the number of programs meeting this metric may be due to programs started since 2010 and the department's implementation of WSARA and the "Better Buying Power" initiatives. Programs started before 2010 have experienced over $469 billion in total acquisition cost growth since their first full estimates whereas programs started after 2010 have experienced over $580 million in decreases. However, these programs have only recently begun development and will need continued oversight to ensure they do not increase in cost in the future.

Seventy-six percent of programs in the 2015 portfolio meet the one year cost performance metric by limiting total acquisition cost growth to less than 2 percent, and 47 percent of programs meet the threshold for less than 15 percent cost growth since first full estimates. Although

a larger share of programs is meeting the 1-year metric than in our last assessment, performance against the first full estimate cost growth threshold is relatively unchanged, remaining less than 50 percent.

10. **Army programs' percentage of the total cost of the major defense acquisition program portfolio is the smallest of the services and has been decreasing since 2007. The percentage attributable to the Navy and Air Force programs' have been increasing since 2007 and 2012 respectively. Navy programs account for almost 55 percent of the 2015 total estimated acquisition cost.** The 79 programs in the current portfolio include three "joint" or DOD-wide programs—the F-35 Joint Strike Fighter, the Joint Light Tactical Vehicle, and Chemical Demilitarization—15 Army programs, 26 Air Force programs, and 35 Navy programs. The Army accounts for almost 10 percent, the Air Force accounts for over 34 percent, and the Navy accounts for almost 55 percent of the portfolio's total acquisition cost in 2015, including the service-specific funding within joint programs. Since 2005, the Army's portion of the portfolio has decreased, the Air Force's portion has increased slightly, and the Navy's portion has increased to its current level of 55 percent from a low of 43 percent in 2007. Figure 6 shows each service's portion of the portfolio's total acquisition cost since 2005.

Figure 6: Services' Percentage of the Portfolio's Total Acquisition Cost, 2005-2015



Source: GAO analysis of DOD data. | GAO-16-329SP

In a constrained funding environment, unforeseen cost growth limits investment choices within DOD. The Navy has historically had more programs than the Air Force and Army. Currently, the Navy has over 30 programs in the portfolio, while the Army has 16 programs including the Joint Light Tactical Vehicle. When looking at total cost, the Navy currently accounts for $785 billion of the $1.4 trillion total acquisition cost. This cost can be expected to grow as the Navy does not include all of the anticipated ships of a class in the Selected Acquisition Reports (SAR) we use to assess programs. For example, while there may be up to 11 Ford–class aircraft carriers delivered, the current cost reporting only accounts for 3. We have reported on many of the Navy's programs and their acquisition challenges.[15]

11. **The equity prices of the contractors delivering the 10 costliest programs have performed well relative to broad-based market indices, indicating that investors expect these firms to remain profitable well into the future.** Five publicly-traded defense contractors are developing and delivering the 10 largest DOD programs in the 2015 portfolio. The equity prices—a stock price-based indicator of investor expectations of future earnings over many years—for these contractors over the past decade has increased at a rate that outperformed broad-based indices for markets as a whole, as well as narrower indices covering similar sectors of the economy.[16] This indicates that investors expect the performance of these companies to be particularly strong for some time to come. Strong equity performance among these contractors could be driven by a

[15]GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture,* GAO-16-84T (Washington, D.C.: Oct. 1, 2015); *Ford-Class Aircraft Carrier: Congress Should Consider Revising Cost Cap Legislation to Include All Construction Costs,* GAO-15-22 (Washington, D.C.: Nov. 20, 2014); *Littoral Combat Ship: Navy Complied with Regulations in Accepting Two Lead Ships, but Quality Problems Persisted after Delivery*, GAO-14-827 (Washington, D.C.: Sept. 25, 2014); *Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost*, GAO-13-530 (Washington, D.C.: July 22, 2013); *Arleigh Burke Destroyers: Additional Analysis and Oversight Required to Support the Navy's Future Surface Combatant Plans*, GAO-12-113 (Washington, D.C.: Jan. 24, 2012); *V-22 Osprey Aircraft: Assessments Needed to Address Operational and Cost Concerns to Define Future Investments*, GAO-09-692T (Washington, D.C.: June 23, 2009); *Defense Acquisitions: Realistic Business Cases Needed to Execute Navy Shipbuilding Programs*, GAO-07-943T (Washington, D.C. July 24, 2007); *Multiyear Procurement Authority for the Virginia Class Submarine Program*, GAO-03-895R: (Washington, D.C.: June 23, 2003).

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

number of factors and is not necessarily related to the financial condition of major acquisition programs.

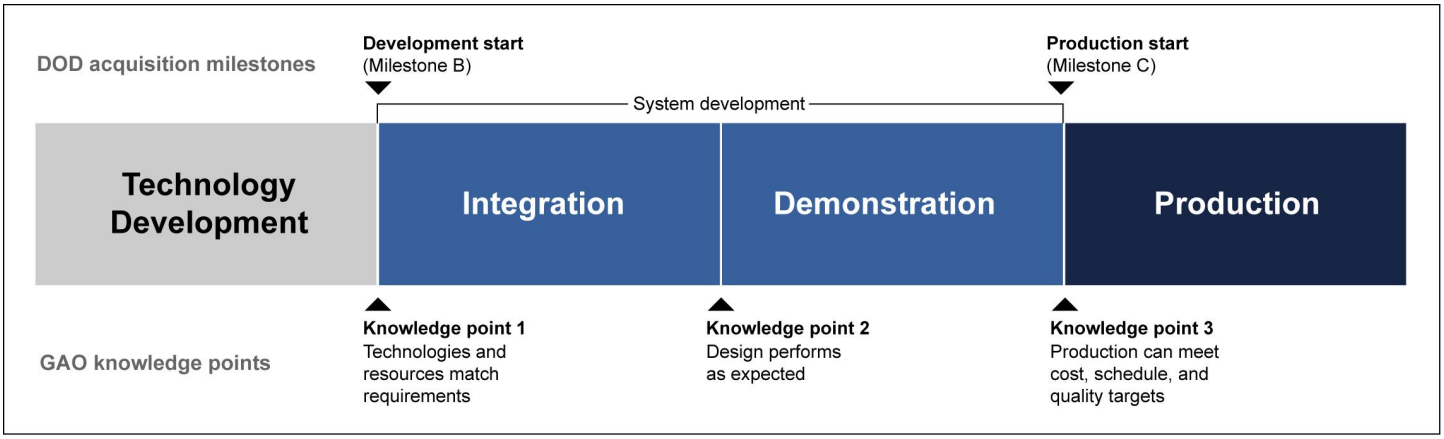
Observations from Our Assessment of Knowledge Attained by Programs at Key Junctures

Our analysis found that while a few programs are using knowledge-based approaches to reduce their acquisition risk, implementation of these approaches across the portfolio has been uneven. For example, programs that recently began system development demonstrated some best practices—such as holding a preliminary design review prior to 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 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 before significant commitments are made. In essence, knowledge supplants risk over time. In our past work examining weapon acquisition and best practices for product development, we have found that leading commercial firms and successful DOD programs pursue an acquisition approach that is anchored in knowledge, whereby high levels of product knowledge are demonstrated at critical points in the acquisition process. This work led to multiple recommendations that DOD generally or partially agreed with and has made progress in implementing.[17] On the basis of this work, we

[17]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).

have identified three key knowledge 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 7 aligns the acquisition milestones described in DOD's primary acquisition policy with these knowledge points. In this report, we refer to DOD's engineering and manufacturing development phase as system development. Production start typically refers to a program's entry into low-rate initial production.



Source: GAO. | GAO-16-329SP

Figure 7: DOD's Acquisition Cycle and GAO Knowledge Points

As our prior work has shown, the building of knowledge consists of information that should be gathered at 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 have been demonstrated to work in a relevant 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 detailed 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, as well as the three-dimensional product model by the start of construction for a new ship. Programs can also improve the stability of their design 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 postproduction 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 build 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 43 current programs, most of which are in development or early production.[18] 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 12 future major defense acquisition programs identified by DOD expect to attain when they start system development in the coming years.[19]

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

[18]Because knowledge points and best practices differ for shipbuilding programs, we exclude the five shipbuilding programs from parts of our analysis at each of the three knowledge points, for more information see appendix I.

[19]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” section of appendix I for more information.

Knowledge Point Observations

1. Of the seven programs that began, or are planning to begin, system development during our assessment period, none have demonstrated a full match between resources and requirements. One program plans to enter system development with immature technologies whereas the rest will have technologies approaching full maturity. Five of the seven programs completed a preliminary design review before development start. Two did not conduct all of the early system engineering reviews recommended by best practices. All but one program plan to constrain their development phase to 6 six years or less. The implementation of best practices by these programs is better from what we have previously observed.
2. Of the five programs that held, or are planning to hold, a critical design review during our assessment period, two met all of the best practices. Two of the programs have not fully demonstrated mature technologies, but all plan to release at least 90 percent of drawings. Three of 5 programs plan to test a system-level integrated prototype to determine the effectiveness of their designs. This is an improvement over our previous assessment when none of the programs implemented all of the best practices.
3. Of the five programs that held or plan to hold a production decision during our assessment period, one met all of the best practices including demonstrating that their manufacturing process capabilities are in control.[a] Three of the programs do not plan to test a production-representative prototype before making a production decision, but all state that they have demonstrated processes on a pilot production line. Overall implementation is better than what we have observed in the past.

Source: GAO analysis of DOD data. | GAO-16-329SP

[a]In DOD's technical comments on a draft of this report, we were informed that the MQ-4C Triton's production decision has been delayed to May 2016.

1. **The seven programs that started system development, or had plans to do so in 2015, have knowledge deficits which undermine the foundation needed to avoid future cost and schedule problems. One program plans to begin system development with immature technologies and none of the seven programs demonstrated critical technologies in an operational environment. Five programs conducted all systems engineering reviews, including a preliminary design review, before entering system development while one program conducted one of these reviews. Six programs plan to limit their development phase to 6 years or less whereas one has yet to determine the length of its development phase.** 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.[20] Our current assessment shows that the implementation of best practices by the 7 programs starting development is better from what we have previously observed. Figure 8 shows the extent to which recommended acquisition practices for knowledge point 1 have been implemented for the seven programs that recently started system development or plan to do so in early 2016: Amphibious Combat Vehicle (ACV), B-2 Defensive Management System Modernization (B-2 DMS-M), Common Infrared Countermeasures (CIRCM), Joint Air-to-Ground Missile (JAGM), Military GPS User Equipment Increment 1 (MGUE), Next Generation Jammer Increment 1 (NGJ Inc 1), and Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)—as well as the other 36 current programs we assessed which accomplished this knowledge point previously.

Figure 8: Implementation of Knowledge-Based Practices for Programs at System Development Start

[20]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999) and 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).

Knowledge-based practices at system development start	ACV	B-2 DMS-M	CIRCM	JAGM	MGUE	NGJ Inc. 1	OASuW Inc. 1	Other 36 programs ●	○	––
Demonstrate all critical technologies in a relevant environment	●	●	●	●	●	●	○	20	8	8
Demonstrate all critical technologies in an operational environment	○	○	○	○	○	○	○	3	23	10
Complete system functional review and system requirements review before system development start	○	●	●	●	●	●	●	10	25	1
Completed preliminary design review before system development start	○	●	●	○	●	●	●	13	22	1
Constrain system development phase to 6 years or less	●	●	●	●	––	●	●	22	6	8

● Practice implemented

○ Practice not implemented

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

ACV - Amphibious Combat Vehicle
B-2 DMS-M - B-2 Defensive Management System Modernization
CIRCM - Common Infrared Countermeasures
JAGM - Joint Air-to-Ground Missile
MGUE - Military GPS User Equipment Increment 1
NGJ Inc. 1 - Next Generation Jammer Increment 1
OASuW Inc. 1 - Offensive Anti-Surface Warfare Increment 1

Source: GAO analysis of DOD data. | GAO-16-329SP

Demonstrate Technology Maturity

We assessed to what level programs starting system development matured their critical technologies. Federal statute requires that programs generally obtain a certification stating that technologies have been demonstrated in a relevant environment.[21] However, knowledge-based acquisition practices recommend that programs fully mature technologies by demonstrating them in an operational—or realistic—environment prior to starting system development. 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.

[21]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.

One program at development start—OASuW Inc 1—does not plan to demonstrate its critical technologies in even a relevant environment. OASuW Inc 1 is a Navy program initiated in 2013 in response to an urgent operational need and will be developed using an accelerated acquisition strategy. While the program plans to leverage previous technology demonstration efforts, it also plans to begin development in February 2016 with immature technologies. Currently the program has six critical technologies whose basic components have been integrated and tested in a lab environment. The components may be representative of a technically feasible approach but they have not been matured to the point of demonstrating form, fit, and function. Beginning development with low technology maturity adds significant risk to the program's accelerated acquisition.

We found that none of the seven programs that began or were planning to begin system development in 2015 will have fully mature technologies. Fully mature technologies require that the program demonstrate their technologies in an operational environment. For example, the Navy assessed the ACV's critical technologies as fully mature based on a technology readiness assessment approved in December 2014. This assessment was based on the non-developmental nature of the vehicles, the use of mature technology for modifications, and tests and demonstrations of prototype vehicles done for another program, the Marine Personnel Carrier. In contrast, we determined that one of the program's two critical technologies had not been tested in an operational environment, as it was not tested at sea, and therefore was not fully mature.[22]

Of the remaining 36 programs, 3 reported that all of their critical technologies were demonstrated in an operational environment when they began development, while 23 programs reported that their technologies had not reached full maturity. Of all of the programs in our assessment, just 7 percent began system development with fully mature technologies.

[22]GAO, *Amphibious Combat Vehicle: Some Acquisition Activities Demonstrate Best Practices; Attainment of Amphibious Capability to be Determined*, GAO-16-22 (Washington, D.C.: October 28, 2015).

We examined whether programs started before or after 2010 are meeting best practices and their subsequent levels of cost growth. Of the 36 programs we assessed for technology readiness, 20 began system development before 2010, 15 after, and one did not hold a system development start. Eight of the 20 programs began development with immature technologies. Since they began system development they have collectively realized almost $32 billion in development cost growth. In contrast, the seven programs that started development with fully mature technologies before 2010 have realized just $286 million, in development cost growth. The remaining 5 programs did not report on the technology maturity at this point.

Complete Systems Engineering Reviews before Development Start

Knowledge-based acquisition practices recommend that programs hold systems engineering events before the start of system development:

- A system requirements review ensures that requirements have been properly identified and that there is a mutual understanding between the government and the contractor.
- A system functional review establishes a baseline for the planned system.
- A preliminary design review establishes that requirements are defined and feasible, and that the proposed design can meet those requirements within cost, schedule, and other system constraints.

We found that six programs that began or plan to begin system development, completed system functional and system requirements reviews prior to starting system development and one did not. This is an improvement over the other 36 programs we assessed.

WSARA established a statutory requirement to conduct a preliminary design review prior to entering system development.[23] Among the

[23]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).

seven programs that started system development in 2015, or planned to in early 2016, five of them conducted a preliminary design review before beginning system development. The other two programs received a waiver to this requirement and expect to conduct this review after their system development start. Thirteen of the other 36 programs held a preliminary design review before the start of system development. Nearly 60 percent of programs that began development since 2010 are implementing this practice compared to 25 percent of programs that began development before 2010, an improvement over our prior assessment.

Constrain System Development Phase to 6 years or Less

Knowledge-based acquisition practices also recommend that a program constrain the system development phase to 6 years or less. Our review of the seven programs that began, or plan to begin, system development during our review period found that six of the seven currently plan to do so. One program in our assessment has not determined when it will end system development and enter production.

For the remaining 36 programs we assessed, 22 planned to limit their system development phase to six years or less at the time they started system development.[24] Plans to constrain the development phase at the start of system development are not always successful. For example, 5 of the programs we assessed took longer to reach production than the six years or less they originally planned. One of these programs began development with immature technologies and 4 had technologies approaching maturity. As a group, they reported approximately $2.1 billion in development cost growth from first full estimates. Sixteen programs plan to enter production in the future, but additional delays may occur, especially as a number of these programs have not implemented all of the best practices for system development.

[24]We did not assess shipbuilding programs against this recommended practice to limit the development phase, as their development cycles do not align in a manner consistent with other programs.

Begin Future Programs with Adequate Knowledge

As part of our analysis, we also assessed 12 programs scheduled to start system development and become major defense acquisition programs in the near future. The greatest point of leverage to ensure a program's success is at the start of a new program. At this point, decision makers can ensure that new programs implement best practices and exhibit desirable principles before they are approved and funded. These programs provided information on the knowledge they planned to obtain and the best practices they intend to implement before system development start. Five of the 12 identified critical technologies and their anticipated maturity levels expected at system development start. Two programs—the Unmanned Carrier-Launched Airborne Surveillance and Strike system and the Fleet Replenishment Oiler—reported that they expect their critical technologies to be fully mature. Table 6 shows this and that the remaining programs reported that their critical technologies would not be fully mature or have not been identified and one program's technology maturity is to be determined at the time of their system development start.

Table 6: Projected Implementation of Knowledge-Based Practices for Future Programs

	DevelNot plannedpment start	PrNot plannedjected tNot planned demNot plannednstrate all critical technNot plannedlNot plannedgies in an Not plannedperatiNot plannednal envirNot plannednment	PrNot plannedjected tNot planned cNot plannedmplete all systems engineering reviews	Plan tNot planned cNot plannednstrain system develNot plannedpment
Fleet Replenishment NOT PLANNEDiler	06/2016	Planned	NOT PLANNED	Planned
Indirect Fire PrNot plannedtectiNot plannedn Capability, Increment 2	06/2016	Not identified	Planned	Planned
F-15 Eagle Passive/Active Warning and Survivability System	09/2016	NOT PLANNED	Planned	Planned
NOT PLANNEDhiNot planned-Class Replacement	09/2016	Not identified	NOT PLANNED	NOT PLANNED
Presidential Aircraft RecapitalizatiNot plannedn	03/2017	Not identified	NOT PLANNED	NOT PLANNED
P-8A Increment 3	06/2017	Not identified	NOT PLANNED	NOT PLANNED
Unmanned Carrier-Launched AirbNot plannedrne Surveillance and Strike	06/2017	Planned	—-	NOT PLANNED

	DevelNot plannedpment start	PrNot plannedjected tNot planned demNot plannednstrate all critical technNot plannedlNot plannedgies in an Not plannedperatiNot plannednal envirNot plannednment	PrNot plannedjected tNot planned cNot plannedmplete all systems engineering reviews	Plan tNot planned cNot plannednstrain system develNot plannedpment
JNot plannedint Surveillance Target Attack Radar System Recap	09/2017	—-	Planned	Planned
ImprNot plannedved Turbine Engine PrNot plannedgram	06/2018	NOT PLANNED	NOT PLANNED	NOT PLANNED
AmphibiNot plannedus Ship Replacement	09/2018	Not identified	NOT PLANNED	NOT PLANNED
Advanced PilNot plannedt Training	12/2017	Not identified	NOT PLANNED	Planned
Weather Satellite FNot plannedllNot plannedw-NOT PLANNEDn	12/2018	NOT PLANNED	NOT PLANNED	NOT PLANNED

Legend

● Implementation planned

O No implementation planned

—- Practice to be determined

Critical technologies have not been identified per the program office response

Source: GAO analysis of DOD data. | GAO-16-329SP

Three of the 12 programs plan to conduct all of the recommended systems engineering reviews before development start, including a system functional review, a system requirements review, and a preliminary design review. Unlike the programs that held system development start in the past year, only four of the 12 future programs plan to hold a preliminary design review before the start of system development. While five of the 12 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.

If DOD decides to let these programs proceed without the knowledge required to achieve a requirements and resource match this will have larger implications than the expected outcomes on these programs. It sends a signal across the entire portfolio of current and future programs about what is acceptable in terms of following a knowledge-based acquisition approach. It is imperative that top decision makers ensure that new programs exhibit desirable principles that embody knowledge-based acquisition best practices before they are approved

and funded at the start of system development, one of the key points in the acquisition cycle where discipline and accountability can be established and reinforced.

2. **Of the five programs that held, or are planning to hold, a critical design review during our assessment period, two met all of the best practices. Two of the programs have not demonstrated mature technologies, and all plan to release at least 90 percent of drawings. Three of 5 programs plan to test a system-level integrated prototype.** For this knowledge point 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 found an improvement over our previous assessment in programs' implementation of best practices at their critical design review. 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 9 below outlines the implementation of this, as well as other, best practices among the programs we assessed.

Figure 9: Implementation of Knowledge-Based Practices for Programs at Critical Design Review

Knowledge-based practices at critical design review	ACV	AMDR	F-22 Inc. 3.2B	JAGM	Space Fence Inc. 1	Other 26 programs ●	Other 26 programs ○	Other 26 programs ––
Demonstrate all critical technologies in an operational environment	○	○	●	●	●	3	17	6
Release at least 90 percent of drawings or 100 percent of 3D zones	●	●	●	●	●	6	11	9
Test an early system-level integrated prototypes	○	●	●	●	○	1	20	5
Establish a reliability growth curve	●	●	●	●	●	17	6	3
Identify key product characteristics	●	●	●	●	●	23	0	3
Identify critical manufacturing processes	●	●	●	●	●	21	1	4
Conduct producibility assessments to identify manufacturing risks for key technologies	●	●	●	●	●	20	3	3
Complete failure modes and effects analysis	●	●	●	●	●	20	2	4

● Practice implemented

○ Practice not implemented

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

ACV - Amphibious Combat Vehicle
AMDR - Air and Missile Defense Radar
F-22 Inc. 3.2B - F-22 Increment 3.2B Modernization
JAGM - Joint Air-to-Ground Missile
Space Fence Inc. 1 - Space Fence Ground-Based Radar System Increment 1

Source: GAO analysis of DOD data. | GAO-16-329SP

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 in maturing technologies cause revisions.

Two programs do not plan to meet this best practice before completing their critical design review—ACV and AMDR. At the time of our review, the ACV program was scheduled to hold their critical design review in February, but this may be delayed due to a bid protest related to the development contract awards. The ACV program's current level of technology maturity is discussed in the previous section. AMDR has four critical technologies that have been

demonstrated in a relevant, but not an operational environment, at the time of its critical design review.

To assess the effect of technology maturity on cost over time, we examined the 22 programs that started development 5 or more years ago and the level of their technology maturity at the time of their critical design review. Of these 22 programs, seven held their critical design review with immature technologies. These programs have realized an average of 74 percent, or $30 billion, in development cost growth over their initial cost estimates. Five of these programs are among those mentioned in the previous section that started system development with immature technologies with the addition of the M109A7 Family of Vehicles and Family of Advanced Beyond Line-of-Sight Terminals (FAB-T). In contrast, 9 programs had technologies approaching maturity or fully mature at their critical design review. These programs have realized an average of 33 percent, or $3.2 billion, in development cost growth, significantly less than the programs with immature technologies.

Demonstrate System Design Stability

Of the five programs that held, or plan to hold, their critical design review in 2015, all demonstrated or are expected to demonstrate design stability by releasing over 90 percent of their expected design drawings. This is an improvement over our prior assessment, in which both programs we assessed had not met this practice. When compared to the other 26 programs we assessed that held critical design reviews previously; 6 met this best practice, 11 had not, and 9 reported that the practice was not applicable.

Testing of a system-level integrated prototype is useful for demonstrating that a system will work as intended and can be built within cost and schedule. Two of the five programs that held, or plan to hold, their critical design review in 2015 did not, or will not, test a system-level integrated prototype prior to their design review—ACV and Space Fence, Inc 1. The ACV program reported completing this practice on another vehicle prototype. This vehicle was not the same design as the current ACV. As a result, GAO determined that this test did not meet the best practice as it did not include all of the key subsystems and components that will be in the ACV. The Space Fence Inc 1 program is developing a large, ground-based radar intended to track objects in Earth's orbit. The program conducted its design review in June 2015 and completed at least 90 percent of its design drawings, but did not demonstrate its ability to meet performance requirements with testing of a system-level integrated

prototype. The program plans to verify the design through testing on a fully configured prototype, with some production-representative elements, beginning in 2016 after the start of production.

We assessed 26 other programs that held a critical design review prior to 2015, and found that only one tested an early integrated prototype before its critical design review. For the other programs, early integrated prototype testing occurred or will occur after their critical design reviews. In some cases this testing will occur years later. We did not assess shipbuilding programs against this knowledge-based acquisition practice as testing early system prototypes in these programs may not be practical as 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.

The five programs we assessed all plan to implement the last five knowledge-based practices shown in figure 9 to increase confidence in the stability of their product's design and its effect on production. This includes practices such as establishing a reliability growth curve and identifying key product characteristics in preparation for production activities. For the other 26 programs in this assessment that have already entered production, a majority of them reported using each of these practices.

Prepare for Production

3. **Of the five programs that held a production decision during our assessment period, one met all of the best practices, including demonstrating that their manufacturing process capabilities are in control. Three of the programs do not plan to test a production-representative prototype before making a production decision. All five state that they have demonstrated manufacturing processes on a pilot production line.** 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. Overall we found better implementation of best practices at this point than what we have observed in the past. Figure 10 shows the extent to which programs that have held a production decision have implemented associated knowledge-based practices.

Figure 10: Implementation of Knowledge-Based Practices for Programs at Production Decision

Knowledge-based practices at production start	FAB-T	JLTV	MQ-4C[a]	SDBII	SSC	For the 11 non-shipbuilding programs that have reached this juncture[b] ●	○	––
Demonstrate all critical technologies in an operational environment	○	●	●	●	●	5	3	3
Release at least 90 percent of drawings or 100 percent of 3D zones	●	––	●	●	●	7	2	2
Demonstrate manufacturing process capabilities are in control	○	○	○	●	○	1	7	3
Demonstrate critical processes on a pilot production line	●	●	●	●	●	6	3	2
Test a production-representative prototype in its intended environment	○	●	○	●	○	4	7	0

● Practice implemented

○ Practice not implemented

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

FAB-T - Family of Advanced Beyond Line-of-Sight Terminals
JLTV - Joint Light Tactical Vehicle
MQ-4C - MQ-4C Triton Unmanned Aircraft System
SDB II - Small Diameter Bomb Increment II
SSC - Ship to Shore Connector Amphibious Craft

Source: GAO analysis of DOD data. | GAO-16-329SP

[a]In DOD's technical comments on a draft of this report, we were informed that the MQ-4C Triton's production decision has been delayed to May 2016.

[b]Shipbuilding programs are not included in the assessment of best practices at production decision.

Demonstrate Manufacturing Processes Are in Control

Four of the five programs that have held recent production decisions did not demonstrate that their manufacturing process capabilities were in control. Small Diameter Bomb Increment II was the only program that satisfied this best practice. The programs not meeting this practice are tracking manufacturing readiness levels, although none of the programs reached the best practices recommended level of readiness. 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 11 non-ship programs we assessed that held production decisions prior to 2015, 1 provided data indicating that critical manufacturing processes were in control at the time of their production start.

Demonstrate Critical Processes on a Pilot Production Line

All of the programs that held a production decision over the past year demonstrated critical processes on a pilot production line. Of the programs we assessed, 17 plan to hold a production decision in the future and they all indicated that they intended to test a pilot production line before production start. Demonstrating critical processes on a pilot production line is an important initial step to ensure that all critical manufacturing processes are repeatable, sustainable, and capable of consistently producing parts within the product's quality tolerances and standards—at the start of production. Of the 11 non-ship programs that held productions decisions in the past, only six have demonstrated this best practice whereas two did not and three programs replied that the practice was not applicable.

Test a Production-Representative Prototype in Its Intended Environment

Our body of work on a knowledge-based approach shows that production and postproduction 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. Of the 5 programs that recently accomplished this milestone, 2 plan to meet this best practice and 3 do not. The three programs—FAB-T, MQ-4C, and SSC—plan to complete this testing from 10 months to over a year after their production decision dates. Of the 17 programs that plan to hold their production decision in the future, 9 report that they intend to test a fully configured prototype. In not conducting testing of production-representative prototypes prior to beginning manufacturing, programs risk discovering issues 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 11 non-ship programs with production decisions in the past, four reported testing a production-representative prototype before this decision whereas seven did not.

Observations about DOD's Implementation of Key Acquisition Reform Initiatives and Program Concurrency

Over the past 5 years, increasing numbers of DOD programs have been implementing acquisition reform initiatives such as those in WSARA, and the "Better Buying Power" initiatives—many of which have been incorporated into the latest iteration of DOD's Instruction 5000.02.[25] The implementation of these initiatives has led to better acquisition outcomes on some programs. Nevertheless, DOD still faces challenges in fully implementing these reforms. Given the level of DOD's investment in major defense acquisition programs continued attention is warranted.

We focused our analysis on the 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. In addition, we reviewed programs' software development efforts to determine how they monitor and manage these efforts. We also assessed the amount of planned concurrency between developmental testing and production for current programs in the portfolio.

Overall, we found modest improvements across many of the areas we assessed. Compared to our previous assessment, similar proportions of programs have established affordability constraints, and more programs have attempted to determine and realize "should-cost" savings. However, the number of current and future programs using or planning to use competition measures does not show substantial improvement. Other risks to program performance persist as well, as high levels of concurrency between development testing and production may add risk to the portfolio.

Our analysis allows us to make the following five observations concerning key acquisition reform initiatives and program concurrency:

[25]Department of Defense Instruction 5000.02, *Operation of the Defense Acquisition System* (Jan. 2015) ("DOD Instruction 5000.02").

Acquisition Reform and Concurrency Observations

1. Of the 55 current and future programs we assessed, 37 have established an affordability constraint, similar to the implementation rate in our last assessment. The development cost growth for the current programs we assessed with an affordability constraint is 33 percentage points lower than that for programs without a constraint.

2. Of the 43 current programs we assessed, 39 have conducted a "should-cost" analysis resulting in anticipated savings of over $35 billion; approximately $21 billion of these savings have been realized to date.

3. Of the 55 current and future programs we assessed, 43 plan to promote competition at some point during acquisition. Eight of these programs have no plans for competition before or after development start and only half of the future programs we assessed plan to conduct competitive prototyping.

4. Of the 55 current and future programs we assessed, 40 reported software development as a high-risk area. Programs that did not report their software development as high-risk have experienced greater schedule delays. Sixteen of the 43 current programs we assessed plan to concurrently conduct production and software development.

5. Sixteen of the 43 current programs we assessed are in production. Eleven of these programs plan to complete 30 percent or more of their developmental testing concurrent with production. Further, three of these 11 programs plan to place more than 20 percent of its procurement quantities under contract before testing is complete. For the programs we assessed, as concurrency increases, so does total acquisition cost growth.

Additional details about each observation follow.

1. **Of the 55 current and future programs we assessed, 37 have established an affordability constraint, similar to the implementation rate in our last assessment. The development cost growth for programs we assessed with an affordability constraint is 33 percentage points lower than that for programs without a constraint.** In 2010, DOD launched a series of "Better Buying Power" initiatives with the goal of delivering superior capabilities to the warfighter and better value to the taxpayer. One such initiative was the establishment of an affordability analysis that results in cost constraints. This analysis differs from program cost estimates in that the constraint serves as a program requirement to

ensure that the program remains cost-effective.[26] 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 programs we assessed, 30 of 43 have established an affordability constraint. A similar proportion of programs had implemented affordability constraints in our last assessment. Two programs, the B-2 Defensive Management System Modernization and the Next Generation Operational Control System, responded that they do not currently expect to meet their affordability constraints. Of the remaining 13 programs that have not established an affordability constraint, most began system development before this requirement was established.[27] Similarly, of the 12 future programs we assessed, seven reported that they established an affordability constraint.

The effectiveness of these constraints has yet to be widely tested; however, the programs we assessed that had established an affordability constraint experienced a median of 4 percent growth in development costs from their original baselines. By contrast, the programs we assessed without an affordability constraint experienced a median of 37 percent growth in development costs.[28]

2. **Of the 43 current programs we assessed, 39 have conducted a "should-cost" analysis resulting in anticipated savings of over $35 billion; approximately $21 billion of these savings have been realized to date.** DOD's "Better Buying Power" initiatives also

[26]Affordability goals are established at milestone A, the entry into technology development. After systems engineering trade-offs are completed during the technology development phase, these affordability goals then become affordability caps prior to milestone B, the start of system development, when a match is to be made between requirements and resources. We refer to the goals and caps collectively as affordability constraints.

[27]The Gerald R. Ford Class Nuclear Aircraft Carrier program has a congressionally mandated cost cap, which we do not consider the same as the affordability requirement considered in this analysis. As a result we include this program in the total number of programs without an affordability cap.

[28]For this analysis we took the median cost growth associated with each group of programs to mitigate the effects of programs with significant cost changes.

emphasize the importance of driving cost improvements during contract negotiation and program execution to control costs both in the short-term and throughout the product life cycle. 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.

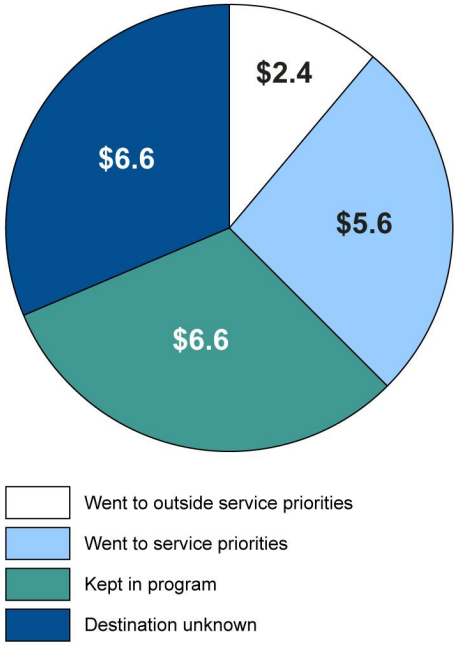
We found that 39 out of 43 current programs conducted a “should-cost” analysis. Three of the four current programs that reported not conducting a “should-cost” analysis are in the process of completing one. Of the 39 programs, 35 identified approximately $35 billion in realized and future savings. Those programs cited several activities as responsible for some or all of their “should-cost” savings, including

- efficiencies realized through contract negotiations (15 programs),
- design trades to balance affordability and capability (12 programs), and
- developmental or operational testing efficiencies (7 programs).

Twenty-six of the 35 programs reported $21.2 billion in realized “should-cost” savings. Of this amount $3.4 billion in savings accrued from savings in development costs, $17.6 billion from procurement costs, and $0.2 billion from other sources. Programs also provided insight as to how their realized savings were allocated. Figure 11 shows the amount of savings reallocated to other purposes.

Figure 11: Priorities for the $21.2 Billion in Total Realized "Should-Cost" Savings

Realized "should-cost" savings
(in fiscal year 2016 dollars billion)



Source: GAO analysis of survey data. | GAO-16-329SP

Of the $21.2 billion in realized "should-cost" savings, $6 billion was kept within the programs to fund other priorities. Programs reported that nearly $286 million of those savings were used to offset budget cuts required by sequestration. Another $5.6 billion of the realized "should-cost" savings went to priorities within the service to which the program belongs and $2.4 billion went to priorities outside of the service. While delivering value to the taxpayer in the acquisition process is one of DOD's stated objectives, programs may not have strong incentives to realize or report "should-cost" savings if those programs perceive them as resulting in the funding of other DOD priorities. Programs we assessed were unable to account for the destination of roughly a third of the savings they reported.

Current programs that we surveyed expect to realize another $13.8 billion in future should cost savings. Of this amount, $8.5 billion in savings is expected to accrue for development and procurement "should-cost" savings and $5.3 billion is expected from other sources. Of the 12 future programs we assessed, 3 reported having conducted a "should-cost" analysis, and identified $9.6 billion in future

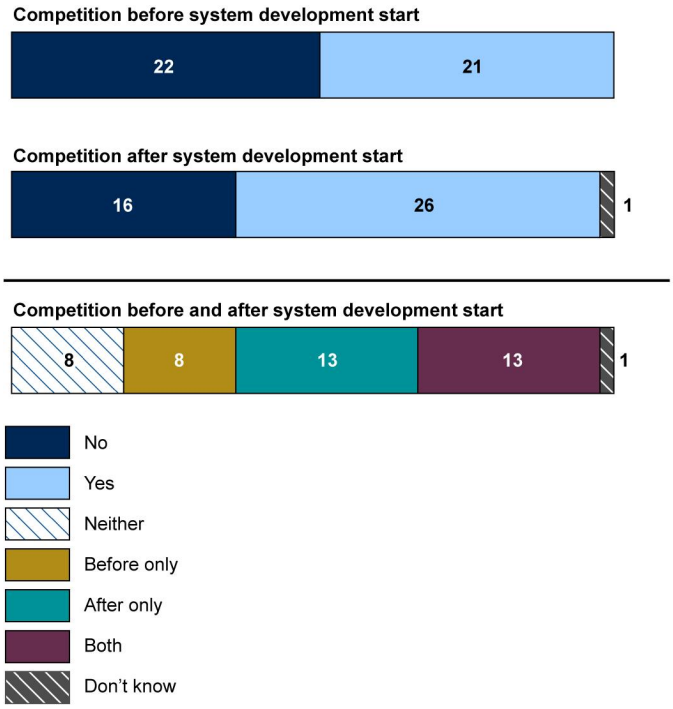
development and procurement savings and an additional $7.9 billion in other savings.

3. **Of the 55 current and future programs we assessed, 43 plan to promote competition at some point during the acquisition cycle. Eight of these programs have no plans for competition before or after development start and only half of the future programs we assessed plan to conduct competitive prototyping.** Competition is a critical tool for achieving the best return on the government's investment. Major defense acquisition programs are generally required to plan for 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.[29] 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.

   Figure 12 shows how current programs plan to promote competition:

[29]Pub. L. No. 111-23, §§ 202, 203, as implemented in DOD Instruction 5000.02. Under certain circumstances this requirement may be waived.

Figure 12: Current Programs' Plans to Promote Competition

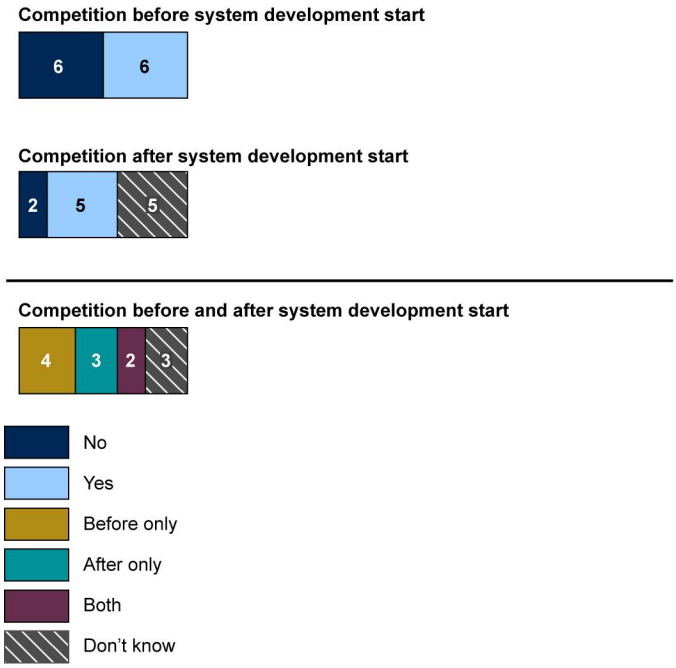


Source: GAO analysis of DOD data. | GAO-16-329SP

Of the 43 current programs we assessed, 21 conducted or planned to conduct competitive prototyping before development start and 26 have acquisition strategies that include some measure to encourage competition after development start, such as funding of next generation prototype systems or subsystems. Thirteen current programs reported pursuing measures to promote competition both before and after the start of system development. These programs experienced less development cost growth than those that promoted competition in only one phase of acquisition. Eight programs reported no plans to pursue competition either before or after beginning system development and one could not describe its current strategy for competition. Six of these are programs new to the portfolio within the last two years.

Figure 13 shows how future programs plan to promote competition:

Figure 13: Future Programs' Plans to Promote Competition



Source: GAO analysis of DOD data. | GAO-16-329SP

Six of 12 future programs reported plans to conduct competitive prototyping before the start of system development; the other six indicated they would not. 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.[30] Programs not taking this step may be missing an opportunity to lower costs and reduce risk. Additionally, five future programs indicated that they would pursue measures to promote competition after the start of system development. Five of the future programs were unable to provide us with information on their plans after development start.

We asked both current and future programs about specific measures they intend to pursue in order to promote competition after the start of

[30]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).

system development. The programs reported most frequently that they have or intend to

- hold periodic system or program reviews to address long-term competitive effects of program decisions,
- use modular, open architectures to enable competition for upgrades; and
- acquire complete technical data packages.

This is significant, as we have previously found that use of these strategies can reduce product development time and life-cycle costs, increase competition and innovation, and enable interoperability between systems.[31]

4. **Of the 55 current and future programs we assessed, 40 reported software development as a high-risk area. Programs that did not report their software development as high-risk have experienced greater schedule delays. Sixteen of the 43 current programs we assessed plan to concurrently conduct production while completing software development.** We found in 2004 that major defense acquisition programs were becoming increasingly reliant on software to achieve their performance characteristics.[32] 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.

   Of the 43 current programs we surveyed, 33 indicated that they had identified software development as a high-risk area. Of the 12 future programs, seven identified their software development as high risk. This is a larger proportion than what we observed in our last assessment, where 25 of 38 current programs identified software development as high-risk. Programs often identified more than one reason for designating software as high risk. The three most common reasons included

   - 27 programs that cited the challenge of completing the software development needed to conduct developmental testing;

[31]GAO, *Defense Acquisitions: Review of Private Industry and Department of Defense Open Systems Experiences,* GAO-14-617R (Washington, D.C.: June 26, 2014).

[32]GAO, Defense Acquisitions: Stronger Management Practices Are Needed to Improve DOD's Software-Intensive Weapon Acquisitions, GAO-04-393 (Washington, D.C.: March 1, 2004).

- 26 programs underestimated the difficultly of their originally planned software effort; and
- 17 programs required hardware design changes, which necessitated additional software development.

A similar proportion of programs in our last assessment identified these issues as motivation for identifying software as a high-risk area, which may indicate that these areas are due additional attention from program managers. Ten programs reported that they had not identified software as a risk, including one program that expects to begin production before completing software development. Those programs experienced, on average, nine additional months of schedule delays compared to programs that had identified software as a high-risk area. In a few cases, those delays are directly attributable to software-development related challenges. The challenges associated with software development have featured in a number of saliently poor acquisition outcomes in DOD, consequently it is encouraging that more programs have begun to identify it as a risk area.

Sixteen of the 43 current programs we assessed plan to begin production prior to completing the software development necessary for integration with system hardware and achieving baseline capabilities, a smaller proportion than our previous assessment. 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. For example, we have reported on the F-35 Joint Strike Fighter program, whose problems necessitated hardware changes to supplement the software or required the acceptance of software whose reliability falls short of overall system requirements.[33]

5. **Sixteen of the 43 current programs we assessed are in production. Eleven of these programs plan to complete 30 percent or more of their developmental testing concurrent with production. Further, 3 of these 11 programs plan to place 20**

[33]GAO, *F-35 Joint Strike Fighter: Problems Completing Software Testing May Hinder Delivery of Expected Warfighting Capabilities,* GAO-14-322 (Washington, D.C.: Mar. 24, 2014).

percent or more of their procurement quantities under contract before testing is complete. For the programs we assessed, as concurrency increases, so does total acquisition cost growth. Development 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-constructed systems.

Eleven of these programs plan to complete a significant portion of their testing—30 percent or more—after they start production. When we examined the relationship between concurrency and total cost growth for programs in production, we found that as concurrency increases, so does the total acquisition cost growth. We also found that programs with higher total costs tend to be more concurrent than programs with lower total costs. A number of relatively expensive and concurrent programs have yet to enter production, exposing them to increased risk of design changes and costly retrofits. Our previous work has found that highly concurrent acquisition strategies can result in poor cost, schedule, and performance outcomes.[34]

Three of these 11 programs plan to place more than 20 percent of their procurement quantities under contract before testing is complete. For example, the AIM-9X Block II program reported that it had about 33 percent of its total procurement quantity under contract, at a cost of approximately $961 million, before completing development testing.

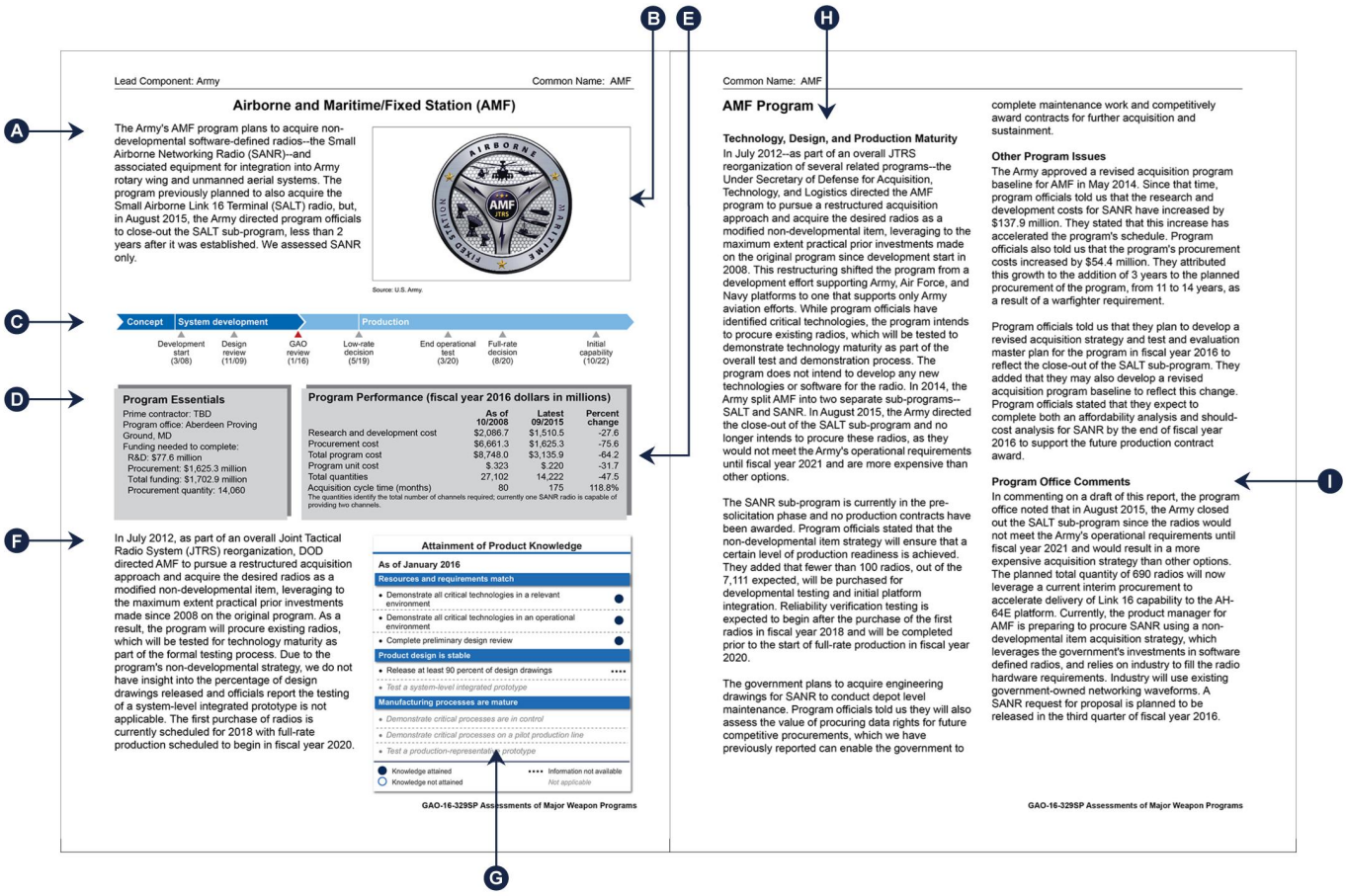
Assessments of Individual Programs

This section contains assessments of individual weapon programs which are grouped by lead service—Army, Navy and Marine Corps, Air Force, and DOD-led—and include 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

[34]GAO, *Ford Class Aircraft Carrier: Poor Outcomes Are the Predictable Consequences of the Prevalent Acquisition Culture*, GAO-16-84T (Washington, D.C.: October 1, 2015).

separator page summarizes information about the acquisition phase, current estimated funding needs, cost and schedule growth, and product knowledge attained provided in the assessments that follow. In total, we present information on 55 programs. For 42 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. Thirty-nine of these 42 two-page assessments are of major defense acquisition programs, most of which are in development or early production, and three assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. See figure 14 for an illustration of the layout of each two-page assessment. In addition, we produced one-page assessments on the current status of 13 programs, which include 12 future major defense acquisition programs and one major defense acquisition program that is well into production.

Figure 14: Illustration of Program Two-Page Assessment



Source: GAO analysis. | GAO-16-329SP

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. As illustrated in figure 14 above, the scorecard displays eight 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 detailed 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 15 for examples of the knowledge scorecards we use to assess these different types of programs.

Figure 15: Examples of Knowledge Scorecards

Program in production

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	●
• Complete preliminary design review	●
Product design is stable	
• Release at least 90 percent of design drawings	●
• Test a system-level integrated prototype	●
Manufacturing processes are mature	
• Demonstrate critical processes are in control	○
• Demonstrate critical processes on a pilot production line	○
• Test a production-representative prototype	●

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

Shipbuilding program

Attainment of Product Knowledge

As of January 2016

Resources and requirements match	
• Demonstrate all critical technologies in a relevant environment	●
• Demonstrate all critical technologies in an operational environment	○
• Complete preliminary design review	●
Product design is stable	
• Complete three-dimensional product model	●
• *Test a system-level integrated prototype*	
Manufacturing processes are mature	
• *Demonstrate critical processes are in control*	
• *Demonstrate critical processes on a pilot production line*	
• *Test a production-representative prototype*	

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

Source: GAO. | GAO-16-329SP

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 accepted on the Electronic Subcontracting Reporting System (eSRS).[35] We reviewed this information for 79 of the major defense acquisition programs in our assessment that reported contract information in their December 2014 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 accepted 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 this data is not captured in the individual subcontracting reports. Information gathered for this analysis is presented in appendix VI.

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

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See separate PDF of weapon program assessments.

Agency Comments and Our Evaluation

We are not making recommendations in this report. DOD provided written comments on a draft of this report. The comments are reprinted in appendix VII. We also received technical comments from DOD, which were incorporated as appropriate.

In its comments, DOD noted that it was pleased that our report identifies ways in which the department continues to drive down the cost of the acquisition portfolio. DOD attributes this decrease in overall cost to the employment of the “Better Buying Power” initiatives. The department also provided a chart tracking the 5-year moving average of annual growth in contract costs over the past 30 years, a measure not used in our analysis, which shows a decline in such growth following the implementation of “Better Buying Power.” We have not included this chart in the appendix as there could be other explanations for this decrease.

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 Rodney Frelinghuysen
Chairman
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 size, cost, and schedule of Department of Defense's (DOD) 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 was entered correctly. We converted all cost information to fiscal year 2016 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2016 (table 5-9). To assess the reliability of the SAR data we talked with a DOD official responsible for DAMIR's data quality control procedures and reviewed relevant documentation. We also confirmed selected data reliability with program offices. 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 size, cost, and schedule changes over the past year, five years, and from baseline estimates that utilize SAR data from December 2014, December 2013, December 2009, 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 79 major defense acquisition programs with SARs dated December 2014 as DOD's 2015 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

[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.

maintenance, total acquisition cost, and schedule estimates for the 79 programs in the 2015 portfolio.[2]

We divided two programs into two distinct elements, because DOD reports performance data on them separately. As a result some of our analysis reflects a total of 81 programs and sub-elements. The Missile Defense Agency's Ballistic Missile Defense System is excluded from all analyses as the program does 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.

For our first observation, we compared the 2015 portfolio with the programs that issued SARs in December 2013 (2014 portfolio) to identify the programs that exited and entered the current portfolio. We accounted for their cost as well as the difference in cost between the two portfolios.

For the second observation, we aggregated funding stream data for the total planned investment of each portfolio from DAMIR for each year since 2005 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 2005, we used funding stream data obtained from DAMIR for each December SAR submission for the years 2004 (2005 portfolio) through 2014 (2015 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 2015 for the December 2014 submission) and earlier, while funding remaining is all the amounts that DOD anticipates will be needed in the fiscal years after the annual SAR submission (fiscal year 2016 and later for the December 2014 submission).

For our third observation, we determined the cost and schedule changes on defense acquisition programs in the current portfolio over the past year, five years, and from baseline estimates. To do this, we collected data from December 2014, December 2013, December 2009, and from

[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.

programs' initial SARs; acquisition program baselines; and program offices.

For programs less than a year old, we calculated the difference between the December 2014 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 five years old, we took a similar approach when calculating the cost and schedule change over the past five years.

For the fourth observation we used SAR data to determine which 10 programs had the largest total acquisition cost, their age, and the total cost and cost growth since first full estimates for two groups of programs—programs started in the past 5 years and program started 5 or more years ago.

For our fifth observation, we 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 our sixth observation, in order to determine whether programs experienced an increase or decrease in buying power over the past year and five years, we used data on the programs' number of procurement units, procurement cost changes, and average procurement unit costs.

We first calculated the amount of procurement cost growth attributable to quantity changes. To do this, we multiplied any change in quantity by the average procurement unit cost for the program a year ago.

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. To determine whether any trends in buying power changes occurred over the past five years, once we conducted the calculations just described, we excluded any programs that were not in each of the past five portfolios. As a result, we examined 61 major defense acquisition

programs for their buying power increases or decreases over the past five years.

For our seventh observation, we used schedule information from the SARs and calculated the acquisition cycle time from program development start to initial operational capability and any delay in achieving initial operational capability. For programs that do not have a development estimate, we compared the current estimate to the production estimate. For shipbuilding programs with a planning estimate, we compared the current estimate to the planning estimate. For programs that began as pre–major defense acquisition programs, the first full estimate we used as a cost and schedule baseline may differ from the baseline disclosed in the program's initial DOD SAR submission.

For programs in the current portfolio where schedule data for initial operational capability was not available over the past year and five years, we used a similar methodology as used when calculating cost change for programs that are less than a year old and less than five years old.

For our eighth observation, we determined which programs reported a development cost estimate increase more than 2 percent over the past year and determined how many of these were in production.

For the ninth observation, we evaluated program performance against high-risk criteria discussed by DOD, the Office of Management and Budget (OMB), 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 five 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 2011-2015 portfolios 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 10th observation we used funding stream data from SARs to analyze the percent of total acquisition cost in the 2005-2015 portfolios that is accounted for by each of the services. Where the Department of Defense is identified as the lead component, we allocated the service-specific portion of total acquisition costs: for the F-35 Joint Strike Fighter, to the Air Force and the Navy; and for the Joint Light Tactical Vehicle, to

the Army and Navy. The Chemical Demilitarization program, where DOD is identified as the lead, does not have service-specific funding.

For the 11th observation, we used SAR data to determine which 10 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 2002 to 2014, and compared the returns 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 Selected DOD Programs Using Knowledge-Based Criteria

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 43 current programs and a slightly different questionnaire for the 12 future programs. Both of the questionnaires were sent by e-mail in an attached Microsoft Word form that respondents could return electronically. We received responses from all of the programs we assessed from August to September 2015. 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; conducting follow-up to clarify responses when needed; and verifying the accuracy of a sample of keypunched questionnaires. Our pretests covered each branch of the military to better ensure that the questionnaires could be understood by officials within each branch. We determined that the data were sufficiently reliable for the purposes of this report.

Our analysis of how well programs are adhering to a knowledge-based acquisition approach focuses on 43 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. In particular, we focused on the seventeen programs that crossed these key acquisition points in 2015 or planned to in early 2016 and evaluated their adherence to knowledge based practices.

We also provide information on how much knowledge is obtained at key decision points by programs that accomplished these previously. We also included observations on the knowledge that 12 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.

The 55 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 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 appendix I. See also appendix IV for a list of the practices that are associated with a knowledge-based acquisition approach.

Analysis of Acquisition Initiatives and Program Concurrency

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.” and previous releases of

DOD's "Better Buying Power" memoranda.[3] We analyzed questionnaire data received from the 43 current and 12 future major defense acquisition programs in our assessment to determine the extent to which acquisition reforms have been implemented. We determined which programs have established affordability constraints and, for current programs, examined the median 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.

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 and the metrics programs reported using to manage their software development. 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. We also determined the average difference in schedule delay for programs that identified their software development as high risk versus those that did not.

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. Lastly, we analyzed the correlation between concurrency and total acquisition cost growth for programs in production, and the correlation between total acquisition cost and concurrency.

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

Individual Assessments of Weapon Programs

In total, this report presents individual assessments of 55 weapon programs. A table listing these programs is found in appendix VIII. Out of these programs, 42 are captured in a two-page format discussing technology, design, and manufacturing knowledge obtained and other program issues. Thirty-nine of these 42 two-page assessments are of major defense acquisition programs, most of which are in development or early production and three assessments are of programs that were projected to become major defense acquisition programs during or soon after our review. The remaining 13 programs are described in a one-page format that describes their current status. Those one-page assessments include 12 future major defense acquisition programs and one major defense acquisition program that is well into production.

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 2016 and later. For some future major defense acquisition programs the estimates of funding needed represents only those amounts provided through fiscal year 2020 and are not a full to complete amount.

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 the 55 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 detailed 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 2015 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 2016 dollars. We converted cost information to fiscal year 2016 dollars using conversion factors from the DOD Comptroller’s National Defense Budget Estimates for Fiscal Year 2016 (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. 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 2016 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 79 of the major defense acquisition programs included in our assessment using the contract information reported in their December 2014 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.

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 an operational environment—is the level of technology maturity that constitutes a low risk for starting a product development program.[4] For shipbuilding programs, we have recommended that this level of maturity be achieved by the contract award for detailed design.[5] 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 demonstrated in 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 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

[4]GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999); 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).

[5]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).

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 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 manufacturing readiness levels (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 June 2015 to March 2016, 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 2015 Portfolio of Major Defense Acquisition Programs

Table 7 contains the current and first full total acquisition cost estimates (in fiscal year 2016 dollars) for each program or element in the Department of Defense's (DOD) 2015 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 7: Current Cost Estimates and First Full Estimates for DOD's 2015 Portfolio of Major Defense Acquisition Programs

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	$14,795	$6,835	116.5%	0.9%	5.2%
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	$2,274	$1,718	32.4%	-0.2%	14.5%
AH-64E Apache New Build (AH-64E New Build)	$2,319	$2,542	-8.8%	0.4%	-8.8%
AH-64E Apache Remanufacture (AH-64E Remanufacture)	$13,992	$7,771	80.1%	-0.6%	21.5%
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	$25,069	$11,727	113.8%	0.8%	-3.7%
AIM-9X Block II Air-to-Air Missile (AIM-9X Block II)	$3,506	$4,287	-18.2%	-4.5%	-18.2%
Air and Missile Defense Radar (AMDR)	$5,232	$5,998	-12.8%	-0.5%	-12.8%
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	$3,590	$8,748	-59.0%	2.0%	-59.9%
Airborne Warning and Control System Block 40/45 Upgrade (AWACS Blk 40/45 Upgrade)	$2,837	$2,996	-5.3%	-0.1%	-5.3%
B-2 Extremely High Frequency SATCOM and Computer Increment 1 (B-2 EHF Inc1)	$589	$762	-22.7%	0.5%	-12.6%
B61 Mod 12 Life Extension Program Tailkit Assembly (B61 Mod 12 LEP TKA)	$1,377	$1,403	-1.8%	-1.5%	-1.8%
C-130J Hercules Transport Aircraft (C-130J)	$17,056	$1,018	1575.1%	0.5%	2.2%

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)
C-5 Reliability Enhancement and Re-engineering Program (C-5 RERP)	$7,563	$11,701	-35.4%	-0.4%	-5.5%
CH-47F Improved Cargo Helicopter (CH-47F)	$16,032	$3,454	364.1%	0.2%	8.8%
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	$25,708	$17,765	44.7%	0.2%	7.8%
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	$11,071	$2,835	290.5%	0.4%	28.0%
Combat Rescue Helicopter (CRH)	$8,426	$8,335	1.1%	1.1%	1.1%
Cooperative Engagement Capability (CEC)	$5,777	$3,158	82.9%	2.2%	4.8%
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	$23,066	$37,341	-38.2%	1.2%	6.9%
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	$115,169	$16,297	606.7%	2.9%	12.1%
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	$21,538	$15,827	36.1%	1.1%	10.9%
EA-18G Growler Aircraft (EA-18G)	$15,305	$9,630	58.9%	11.1%	21.2%
Enhanced Polar System (EPS)	$1,425	$1,431	-0.4%	-0.4%	-0.4%
Evolved Expendable Launch Vehicle (EELV)	$60,497	$18,642	224.5%	-2.7%	224.5%
Excalibur Precision 155mm Projectiles (Excalibur)	$1,962	$5,125	-61.7%	0.3%	-26.1%
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	$1,565	$1,608	-2.6%	-1.3%	-2.6%
F-35 Joint Strike Fighter (F-35)	$339,997	$229,285	48.3%	-1.0%	10.1%
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	$4,308	$3,421	25.9%	-10.6%	0.7%
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	$36,438	$38,172	-4.5%	-0.9%	-2.1%
Global Broadcast Service (GBS)	$1,291	$618	109.0%	2.3%	6.0%
Global Positioning System III (GPS III)	$4,918	$4,229	16.3%	4.5%	9.0%
Ground/Air Task Oriented Radar (G/ATOR)	$2,775	$1,573	76.5%	0.0%	76.5%
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	$6,863	$1,897	261.8%	-2.1%	9.3%
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	$13,211	$3,891	239.5%	-2.3%	2.2%
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	$14,424	$8,974	60.7%	-0.7%	60.7%
Integrated Air and Missile Defense (IAMD)	$6,371	$5,395	18.1%	0.8%	18.1%
Integrated Defensive Electronic Countermeasures (IDECM)	$2,680	$2,336	14.7%	0.5%	10.7%
IDECM Block 4	$923	$745	24.0%	1.5%	22.5%
IDECM Blocks 2/3	$1,757	$1,591	10.4%	-0.1%	5.3%
Intercontinental Ballistic Missile Fuze Modernization (ICBM Fuze Mod)	$1,882	$1,870	0.7%	0.7%	0.7%
Joint Air-to-Surface Standoff Missile (JASSM)	$7,346	$2,487	195.4%	0.7%	-6.4%

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)
Joint Direct Attack Munition (JDAM)	$9,205	$3,668	151.0%	10.4%	32.5%
Joint Light Tactical Vehicle (JLTV)	$23,956	$24,178	-0.9%	-0.3%	-0.9%
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	$1,590	$1,086	46.4%	-1.8%	50.3%
Joint Standoff Weapon - Baseline Variant and Unitary Warhead Variant (JSOW)	$4,389	$8,527	-48.5%	-26.2%	-24.4%
JSOW - Baseline Varient	$2,215	$3,065	-27.7%	-7.4%	-7.8%
JSOW - Unitary Warhead Varient	$2,174	$5,462	-60.2%	-38.9%	-36.1%
Joint Tactical Networks (JTN)	$2,316	$1,052	120.1%	-0.3%	6.6%
Handheld, Manpack, and Small Form Fit Radios (HMS)	$9,130	$10,769	-15.2%	-13.0%	75.2%
KC-130J Transport Aircraft (KC-130J)	$9,739	$10,176	-4.3%	-5.9%	-4.3%
KC-46 Tanker Modernization Program (KC-46A)	$43,532	$47,021	-7.4%	-0.4%	-7.4%
LHA 6 America Class Amphibious Assault Ship (LHA 6)	$9,971	$3,412	192.2%	-2.5%	43.3%
Littoral Combat Ship - Mission Packages (LCS MP)	$6,930	$7,031	-1.4%	2.0%	-1.4%
Littoral Combat Ship (LCS)	$20,954	$2,408	NA	-3.0%	NA
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	$21,283	$12,567	69.4%	6.2%	6.4%
M109A7 Family of Vehicles	$7,201	$7,176	0.4%	0.3%	0.4%
MH-60R Multi-Mission Helicopter (MH-60R)	$14,574	$5,940	145.4%	5.3%	-6.7%
Mobile User Objective System (MUOS)	$7,719	$7,211	7.0%	0.2%	3.8%
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	$5,253	$1,089	382.2%	7.5%	-3.2%
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	$12,815	$13,783	-7.0%	-7.2%	-9.7%
MQ-8 (Fire Scout)	$2,918	$2,806	4.0%	-5.9%	8.5%
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	$12,154	$2,829	329.6%	3.8%	0.3%
Multifunctional Information Distribution System (MIDS)	$4,098	$1,399	192.9%	2.7%	28.0%
Navy Multiband Terminal (NMT)	$2,132	$2,490	-14.4%	6.9%	-2.3%
Next Generation Operational Control System (GPS OCX)	$3,737	$3,553	5.2%	5.4%	5.2%
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	$33,269	$33,297	-0.1%	-0.5%	-5.6%
Patriot Advanced Capability-3 Missile Enhancement (PAC-3 MSE)	$6,354	$7,818	-18.7%	-23.5%	-24.0%
Remote Minehunting System (RMS)	$1,574	$1,547	1.8%	2.3%	13.4%
RQ-4A/B Global Hawk Unmanned Aircraft System (RQ-4A/B Global Hawk)	$10,039	$5,786	73.5%	-1.3%	-32.1%
Ship to Shore Connector Amphibious Craft (SSC)	$4,087	$4,242	-3.7%	-0.5%	-3.7%

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)
Small Diameter Bomb Increment II (SDB II)	$3,970	$5,045	-21.3%	0.5%	-21.3%
Space Based Infrared System High (SBIRS High)	$19,135	$4,932	288.0%	1.1%	10.1%
Space Fence Ground-Based Radar System Increment 1	$1,588	$1,614	-1.6%	-1.6%	-1.6%
SSN 774 Virginia Class Submarine (SSN 774)	$91,144	$64,857	40.5%	5.5%	1.8%
Standard Missile-6 (SM-6)	$8,963	$6,116	46.6%	-3.9%	34.2%
Tactical Tomahawk RGM-109E/UGM 109E Missile (TACTOM)	$6,255	$2,270	175.5%	5.5%	-16.1%
Trident II (D-5) Sea-Launched Ballistic Missile UGM 133A (Trident II Missile)	$57,803	$55,504	4.1%	0.1%	3.2%
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	$26,273	$13,917	88.8%	2.4%	10.0%
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	$61,891	$43,023	43.9%	0.2%	1.4%
VH-92A Presidential Helicopter Replacement Program	$4,817	$4,790	0.6%	0.6%	0.6%
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	$10,433	$3,979	162.2%	-17.8%	102.0%
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	$2,025	$17,560	-88.5%	-45.2%	-86.3%
Wideband Global SATCOM (WGS)	$4,109	$1,281	220.8%	-1.1%	6.0%

Source: GAO analysis of DOD data. | GAO-16-329SP

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 2015 Portfolio of Major Defense Acquisition Programs over Five Years and Since First Full Estimates

Table 8 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 Department of Defense's (DOD) 2015 portfolio over the last 5 years and since their first full cost and schedule estimates.

Table 8: Cost and Schedule Changes for Programs in DOD's 2015 Portfolio

Fiscal year 2016 dollars (in billions)

	5-year comparison (2010-2015)	Since first full estimate (Baseline to 2015)
Change in total research and development cost	$22.1 8.3%	$102.2 54.7%
Change in total procurement cost	$70.8 6.6%	$364.9 47.2%
Change in total other acquisition costs	$2.8 27.9%	$1.6 14.2%
Change in total acquisition cost[a]	$95.7 7.1%	$468.7 48.3%
Average delay in delivering initial capabilities	10.8 months 11.1%	29.5 months 36.6%

Source: GAO analysis of DOD data. | GAO-16-329SP

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]In addition to research and development and procurement costs, total acquisition cost includes 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 confirms 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. Table 9 summarizes these knowledge points and associated key practices.

Table 9: 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-16-329P

[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

	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-16-329SP

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 accepted during 2015 in the Electronic Subcontracting Reporting System (eSRS). We reviewed this information for 79 major defense acquisition programs included in our assessment that reported prime contract information in their December 2014 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 accepted subcontracting report in eSRS. For example, some contractors may have pending or rejected reports within the system as all reports are reviewed prior to acceptance. Not all prime contracts for major defense acquisition programs are required to submit individual subcontracting reports. Instead, 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]

Table 10: Major Defense Acquisition Programs' Individual Subcontracting Reports in the Electronic Subcontracting Reporting System

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
Advanced Extremely High Frequency (AEHF) Satellite	2	0
AGM-88E Advanced Anti-Radiation Guided Missile (AGM-88E AARGM)	2	2
AH-64E Apache New Build (AH-64E New Build)	1	1
AH-64E Apache Remanufacture (AH-64E Remanufacture)	5	2
AIM-9X Block II Air-to-Air Missile (AIM-9X Block II)	4	0
Air and Missile Defense Radar (AMDR)	1	0
Airborne and Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS)	0	0
AIM-120 Advanced Medium Range Air-to-Air Missile (AMRAAM)	6	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

[1]As of November 2015, 12 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). One additional company ceased participation in 2007, although active contracts awarded before that time are still reported through the test program. 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 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).

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
C-130J Hercules Transport Aircraft (C-130J)	4	0
C-5 Reliability Enhancement and Re-engineering Program (C-5 RERP)	1	0
Cooperative Engagement Capability (CEC)	4	0
CH-47F Improved Cargo Helicopter (CH-47F)	1	1
CH-53K Heavy Lift Replacement Helicopter (CH-53K)	2	0
Chemical Demilitarization-Assembled Chemical Weapons Alternatives (Chem Demil-ACWA)	2	2
Combat Rescue Helicopter (CRH)	1	0
Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	4	3
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	3	3
DDG 51 Arleigh Burke Class Guided Missile Destroyer (DDG 51)	6	5
E-2D Advanced Hawkeye Aircraft (E-2D AHE)	5	2
EA-18G Growler Aircraft (EA-18G)	6	4
Evolved Expendable Launch Vehicle (EELV)	4	3
Enhanced Polar System (EPS)	1	1
Excalibur Precision 155mm Projectiles (Excalibur)	2	0
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	1	0
F-35 Joint Strike Fighter (F-35)	6	0
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	2	0
MQ-8 (Fire Scout)	1	1
Ground/Air Task Oriented Radar (G/ATOR)	1	0
Global Broadcast Service (GBS)	1	0
Guided Multiple Launch Rocket System/Guided Multiple Launch Rocket Sys Alt Warhead (GMLRS/GMLRS AW)	4	0
Global Positioning System III (GPS III)	2	1
Next Generation Operational Control System (GPS OCX)	1	0
H-1 Upgrades (4BW/4BN) (H-1 Upgrades)	5	3
HC/MC-130 Recapitalization Aircraft (HC/MC-130 Recap)	3	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	3	1
Joint Air-to-Surface Standoff Missile (JASSM)	3	0
Joint Direct Attack Munition (JDAM)	2	2
Joint Light Tactical Vehicle (JLTV)	3	2

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
Joint Precision Approach and Landing System Increment 1A (JPALS Inc 1A)	1	0
Joint Standoff Weapon - Baseline and Unitary Warhead Varient (JSOW)	0	0
Joint Tactical Networks (JTN)	0	0
Joint Tactical Radio System Handheld, Manpack, and Small Form Fit Radios (JTRS HMS)	1	0
KC-130J Transport Aircraft (KC-130J)	4	0
KC-46 Tanker Modernization Program (KC-46A)	3	3
Littoral Combat Ship (LCS)	2	1
Littoral Combat Ship - Mission Packages (LCS MP)	1	0
LHA 6 America Class Amphibious Assault Ship (LHA 6)	1	1
LPD 17 San Antonio Class Amphibious Transport Dock (LPD 17)	1	1
M109A7 Family of Vehicles	2	2
MH-60R Multi-Mission Helicopter (MH-60R)	4	0
Multifunctional Information Distribution System (MIDS)	2	2
MQ-1C Gray Eagle Unmanned Aircraft System (MQ-1C Gray Eagle)	5	4
MQ-4C Triton Unmanned Aircraft System (MQ-4C Triton)	1	1
MQ-9 Reaper Unmanned Aircraft System (MQ-9 Reaper)	3	0
Mobile User Objective System (MUOS)	1	0
Navy Multiband Terminal (NMT)	1	0
P-8A Poseidon Multi-Mission Maritime Aircraft (P-8A)	3	2
Patriot Advanced Capability-3 Missile Enhancement (PAC-3 MSE)	3	0
Remote Minehunting System (RMS)	2	0
RQ-4A/B Global Hawk Unmanned Aircraft System (RQ-4A/B Global Hawk)	0	0
Space Based Infrared System High (SBIRS High)	4	0
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)	8	2
UH-60M Black Hawk Helicopter (UH-60M Black Hawk)	1	0
V-22 Osprey Joint Services Advanced Vertical Lift Aircraft (V-22)	5	4

Program name	Number of contracts listed in the December 2014 SAR	Contracts with an accepted individual subcontracting report (as of December 2015)
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	184	69

Source: GAO analysis of data from DOD and eSRS. | GAO-16-329SP

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 9 2016

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-16-329SP, "Defense Acquisitions: Assessments of Selected Weapon Programs" dated March 2016 (GAO Code 121276).

The Department is pleased that this year's Draft Report, the 14th 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 through employment of the Better Buying Power initiatives. The enclosed chart illustrates the five-year moving average of the annual growth of contracted costs over the past thirty years, note that it shows a steep decline in contract cost growth following the implementation of Better Buying Power.

The Department appreciates the opportunity to comment on the Draft Report. My point of contact for this effort is LCDR Joseph Mitzen, 703-697-8020.

Sincerely,

Nancy L. Spruill

Nancy L. Spruill
Director
Acquisition Resources & Analysis

Enclosure:
As stated

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 J. Kristopher Keener, Assistant Director; Enyinnaya David Aja; Desirée E. Cunningham; Matthew T. Drerup; Danny Owens; and Wendy Smythe. Other key contributors included, Cheryl Andrew, Naba Barkakati, Emily Bond, Edwin B. Booth, Jennifer A. Dougherty, Rich Horiuchi, Julia Kennon, Jill N. Lacey, Kate Lenane, Jean L. McSween, Travis J. Masters, LaTonya Miller, Diana L. Moldafsky, Scott M. Purdy, Beth Reed Fritts, Ronald E. Schwenn, Bill Shear, Charlie Shivers, Roxanna T. Sun, Jay Tallon, Lindsay C. Taylor, Bruce H. Thomas, Oziel A. Trevino, and Alyssa Weir. The following were responsible for individual programs:

Current programs Program name	Primary staff
AIM-9X Block II Air-to-Air Missile	Jennifer A. Dougherty, Stephen V. Marchesani, Cale Jones
Air and Missile Defense Radar (AMDR)	Sean D. Merrill, Laura M. Jezewski, Nathan Foster
Airborne & Maritime/Fixed Station (AMF)	Lindsay C. Taylor, Scott M. Purdy
Amphibious Combat Vehicle (ACV)	Jenny Shinn, Zachary Sivo, Betsy Gregory-Hosler
Armored Multi-Purpose Vehicle (AMPV)	Andrea M. Bivens, Marcus C. Ferguson
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, Brian T. Smith
Combat Rescue Helicopter (CRH)	Sean C. Seales, J. Andrew Walker
Common Infrared Countermeasure (CIRCM)	Danny Owens, Wendy Smythe
CVN 78 Gerald R. Ford Class Nuclear Aircraft Carrier (CVN 78)	Burns C. Eckert, Abby C. Volk, Kelsey Hawley
DDG 51 Flight III Destroyer (DDG 51 Flight III)	Laura M. Jezewski, Sean D. Merrill, Nathan Foster
DDG 1000 Zumwalt Class Destroyer (DDG 1000)	Angie Nichols-Friedman, Patrick Breiding, Garrett Riba
Enhanced Polar System (EPS)	Bradley L. Terry, Maricela Cherveny
Evolved Expendable Launch Vehicle (EELV)	Andrew Redd, Erin E. Cohen, Desirée E. Cunningham
F-22 Increment 3.2B Modernization (F-22 Inc 3.2B Mod)	Julie C. Hadley, Robert P. Bullock
F-35 Joint Strike Fighter Aircraft (F-35 JSF)	Megan Sester, Jillena S. Roberts, Samuel Woo

Current programs Program name	Primary staff
Family of Advanced Beyond Line-of-Sight Terminals (FAB-T)	Alexandra Dew Silva, Jessica E. Karnis, Justin Jaynes
Global Positioning System III (GPS III)	Laura T. Holliday, Raj Chitikila
Ground/Air Task Oriented Radar (G/ATOR)	Joe Hunter, Bonita J. P. Oden
Handheld, Manpack, and Small Form Fit Radios (HMS)	Scott M. Purdy, Jessica E. Karnis
Integrated Air and Missile Defense (IAMD)	Carol T. Mebane, Meredith A. Kimmett
Joint Air-to-Ground Missile (JAGM)	Daniel Singleton, Wendy Smythe
Joint Light Tactical Vehicle (JLTV)	Marcus C. Ferguson, Andrea M. Bivens
KC-46A Tanker Modernization Program (KC-46A)	Katheryn S. Hubbell, Nathaniel Vaught Jeffrey L. Hartnett
LHA 6 America Class Amphibious Assault Ship (LHA 6)	Abby C. Volk, Teague A. Lyons, Matthew Jacobs
Littoral Combat Ship (LCS)	Jacob Beier, C. James Madar
Littoral Combat Ship - Mission Modules (LCS Packages)	Laurier R. Fish, Jacob Beier
M109A7 Family of Vehicles (M109A7 FOV)	William C. Allbritton, Richard Cederholm
Military Global Positioning System User Equipment Increment 1 (MGUE)	Raj Chitikila, Andrew Redd
MQ-4C Triton Unmanned Aircraft System (MQ-4C)	Don M. Springman, Tom Twambly
MQ-8 Fire Scout Unmanned Aircraft System (MQ-8 Fire Scout)	James Kim, Justin Jaynes, Jeffrey Harner
Next Generation Jammer Increment 1 (NGJ Increment 1)	Teakoe S. Coleman, Laura T. Holliday
Next Generation Operational Control System (OCX)	Claire A. Buck, Erin R. Cohen, Maricela Cherveny
Offensive Anti-Surface Warfare Increment 1 (OASuW Inc 1)	Tom Twambly, Laurier R. Fish, Ji Byun
Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE)	Meredith A. Kimmett, Carol T. Mebane
Ship to Shore Connector Amphibious Craft (SSC)	Teague A. Lyons, Beth Reed Fritts, Molly Callaghan
Small Diameter Bomb Increment II (SDB II)	John W. Crawford, Carrie W. Rogers
Space Fence Ground Based Radar System Increment 1 (Space Fence Inc 1)	Laura D. Hook, Suzanne Sterling
Three-Dimensional Expeditionary Long-Range Radar (3DELRR)	Claire Li, Joe Hunter
VH-92A Presidential Helicopter (VH-92A)	Bonita J. P. Oden, Robert K. Miller
Warfighter Information Network-Tactical Increment 2 (WIN-T Inc 2)	Andrea Yohe, Ryan Stott
Warfighter Information Network-Tactical Increment 3 (WIN-T Inc 3)	Ryan Stott, Andrea Yohe

Future Programs	Primary Staff
Advanced Pilot Trainer (APT)	Marvin E. Bonner, Sean C. Seales
Amphibious Ship Replacement (LX(R))	Holly Williams, Jenny Shinn, Zachary Sivo
F-15 Eagle Passive Active Warning Survivability System (F-15 EPAWSS)	Wendell K. Hudson, LeAnna M. Parkey
Improved Turbine Engine Program (ITEP)	Wendy Smythe, Daniel Singleton
Indirect Fire Protection Capability Increment 2 – Intercept, Block 1 (IFPC Inc 2, Block 1)	Helena Johnson, James P. Haynes

Future Programs	Primary Staff
Joint Surveillance Target Attack Radar System Recapitalization (JSTARS Recap)	J. Andrew Walker, Sameena Ismailjee, Alexandra Stone
Ohio-class Replacement (Ohio Replacement)	C. James Madar, Christopher J. Yun
P8-A Increment 3 Upgrade Program (P8-A Inc 3)	Heather B. Miller Jocelyn C. Yin
Presidential Aircraft Recapitalization (PAR)	LeAnna M. Parkey, Wendell K. Hudson
Unmanned Carrier Launched Airborne Surveillance and Strike (UCLASS) System	Robert P. Bullock, Julie C. Hadley
Weather Satellite Follow-On (WSF)	Maricela Cherveny, Brenna E. Guarneros

Appendix IX Accessible Data

Data Tables

Data Table for Highlights figure, Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio

Percentage cost change interval	Amount of cost change in each percentage interval over the past year	Number of programs in each percentage cost change interval
< -25%	-3.23	2
-25-20%	-1.95	1
-20-15%	-2.25	1
-15-10%	-1.88	2
-10-5%	-1.79	3
-5-0%	-8.21	28
0-5%	6.73	33
5-10%	7.71	7
10-15%	2.4	2
15-20%	0	0
20-25%	0	0
> 25%	0	0

Data Table for Figure 1: DOD Portfolio Cost and Size, 2005-2015

Portfolio year	Total acquisition cost	Number of programs
2005	1558	90
2006	1647	88
2007	1684	94
2008	1666	95
2010	1699	97
2011	1693	95
2012	1531	85
2013	1546	80
2014	1455	78
2015	1440	79

Data Table for Figure 2: DOD Portfolio Future Development and Procurement Funding in Comparison to Invested Funding by Year, 2005-2015

	Total development and procurement funding invested in the portfolio	Development funding needed to complete the portfolio	Procurement funding needed to complete the portfolio
2005	-618	128	777
2006	-654	113	843
2007	-729	95	821
2008	-818	77	733
2010	-944	51	668
2011	-909	57	691
2012	-811	44	636
2013	-844	37	651
2014	-798	33	611
2015	-823	32	571

Data Table for Figure 3: Distribution of the 1-year Change in Total Acquisition Cost within the 2015 Portfolio

Percentage cost change interval	Amount of cost change in each percentage interval over the past year	Number of programs in each percentage cost change interval
< -25%	-3.23	2
-25-20%	-1.95	1
-20-15%	-2.25	1
-15-10%	-1.88	2
-10-5%	-1.79	3
-5-0%	-8.21	28
0-5%	6.73	33
5-10%	7.71	7
10-15%	2.4	2
15-20%	0	0
20-25%	0	0
> 25%	0	0

Data Table for Figure 4: Distribution of the 1-year Change in Delivery of Initial Operational Capability within the 2015 Portfolio

	Number of months in each delay interval over the past year	Number of programs in each schedule delay interval
< -6	-9	1
-6-0	-3	1
=0	0	58
0-6	13	5
6-12	13	2
12-18	13	1
18-24	0	0
24-30	53	2
30-36	0	0
>36	98	1

Data Table for Figure 5: Comparison of the Cost Performance of DOD's 2011-2015 Portfolios

	Year	Percentage of programs that meet the metric	Percent of programs that do not meet the metric
1-uear comparison (<2% growth)	2011	60	40
	2012	85	15
	2013	76	24
	2014	69	31
	2015	76	24

	Year	Percentage of programs that meet the metric	Percent of programs that do not meet the metric
5-year comparison (<10% growth)	2011	47	53
	2012	56	44
	2013	55	45
	2014		
	2015	72	28

	Year	Percentage of programs that meet the metric	Percent of programs that do not meet the metric
First full estimate comparison (<15% growth)	2011	43	57
	2012	48	52
	2013	44	56
	2014	44	56
	2015	47	53

Data Table for Figure 6: Services' Percentage of the Portfolio's Total Acquisition Cost, 2005-2015

Year	Navy	Air Force	Army	OSD
2005	45.4	30.4	23.5	0.7
2006	44.7	29.2	25.5	0.7
2007	42.8	29.5	26.9	0.8
2008	43.8	29.1	22.7	4.4
2010	49.6	32.3	17.3	0.8
2011	53	29.8	16.2	1
2012	54.2	28.5	16.1	1.1
2013	54.4	32.3	12.2	1.1
2014	53.9	33.2	11.5	1.4
2015	54.6	34.3	9.8	1.4

Data Table for Figure 11: Priorities for the $21.2 Billion in Total Realized "Should-Cost" Savings

Priority	Realized should-cost savings (in fiscal year 2016 dollars billion)
Went to outside service priorities	2.4
Went to service priorities	5.6
Kept in program	6.6
Destination unknown	6.6

Data Table for Figure 12: Current Programs' Plans to Promote Competition

	No	Yes	Neither	Before only	After only	Both	Don't know
Competition before system development start	22	21	NA	NA	NA	NA	NA
Competition after system development start	16	26	NA	NA	NA	NA	1
Competition before and after system development start	NA	NA	8	8	13	13	1

Data Table for Figure 13: Future Programs' Plans to Promote Competition

	No	Yes	Before only	After only	Both	Don't know
Competition before system development start	6	6	NA	NA	NA	NA
Competition after system development start	2	5	NA	NA	NA	5
Competition before and after system development start	NA	NA	4	3	2	3

Related GAO Products

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Navy Shipbuilding: Significant Investments in the Littoral Combat Ship Continue Amid Substantial Unknowns about Capabilities, Use, and Cost. GAO-13-530. Washington, D.C.: July 22, 2013.

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