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DEFENSE ACQUISITIONS

Strong Leadership Is Key to Planning and Executing Stable Weapon Programs

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Strong Leadership Is Key to Planning and Executing Stable Weapon Programs

Why GAO Did This Study

For several decades, Congress and the Department of Defense (DOD) have explored ways to improve the acquisition of major weapon systems, yet program outcomes and their underlying causes have proven resistant to change. Last year, we reported that the cumulative cost growth in DOD's portfolio of major programs was $296 billion. The opportunity to achieve meaningful improvements may now be at hand with the recent introduction of major reforms to the acquisition process.

In response to a mandate from this Committee, GAO has issued several reports about DOD's budget and requirements processes to support weapon program stability. This follow-on report focuses on (1) identifying weapon programs that are achieving good outcomes, (2) the factors that enable some programs to succeed, and (3) lessons to be learned from these programs to guide implementation of recent reforms. GAO analyzed DOD's portfolio of major defense programs and conducted case study reviews of five programs.

What GAO Recommends

While no new recommendations are being made, previous GAO recommendations have been incorporated into recent reforms. In this report, we present lessons learned to help effectively implement these reforms. In written comments, DOD noted that it has recently instituted several major changes to acquisition policy that are aimed at starting programs right.

What GAO Found

While GAO's work has revealed significant aggregate cost and schedule growth in DOD's portfolio of major defense acquisition programs, individual programs within the portfolio vary greatly in terms of cost growth and schedule delays. Our analysis of individual program performance found that 21 percent of programs in DOD's 2008 major defense acquisition portfolio appeared to be stable and on track with original cost and schedule goals. These programs tended to represent relatively smaller investments, with just under 9 percent of total dollars invested in these programs. Programs that appeared to be on track were markedly newer and had development cycles that were shorter than highly unstable programs.

The stable programs we studied were supported by senior leadership, run by disciplined program managers, and had solid business cases that were well-executed. These programs benefited from strong leadership support, in some cases because the programs were perceived as having an immediate need and, therefore, were viewed as a higher priority by senior leaders. Their program managers tended to share key attributes such as experience, leadership continuity, and communication skills that facilitated open and honest decision making. As a result, these programs established sound, knowledge-based business plans before starting development and then executed those plans using disciplined approaches. They pursued evolutionary or incremental acquisition strategies, leveraged mature technologies, and established realistic cost and schedule estimates that accounted for risk. They were able to invest in early planning and systems engineering, and made trade-offs to close gaps between customer needs and available resources to arrive at a set of requirements that could be developed within cost and schedule targets. After approval, the programs resisted new requirements and maintained stable funding. These practices are in contrast to prevailing pressures to force programs to compete for funds by exaggerating achievable capabilities, underestimating costs, and assuming optimistic delivery dates.

Congress and DOD have taken major steps toward reforming the defense acquisition system that may increase the likelihood weapon programs succeed in meeting their planned cost and schedule objectives. Many of these steps are consistent with key elements in our case study analysis. In particular, the new DOD policy and legislative provisions place greater emphasis on front-end planning and establishing sound business cases for starting programs. For example, the provisions strengthen systems engineering and cost estimating, and require early milestone reviews, prototyping, and preliminary designs. They are intended to enable programs to refine a weapon system concept and make cost, schedule, and performance trade-offs before significant commitments are made. Fundamentally, the provisions should help programs replace risk with knowledge, and set up more executable programs. If reform is to succeed, however, programs that present realistic strategies and resource estimates must succeed in winning approval and funding.

_____ **United States Government Accountability Office**

Contents

Abbreviations

ACTD	Advanced Concept Technology Demonstration
ARH	Armed Reconnaissance Helicopter
DAMIR	Defense Acquisition Management Information Retrieval
DOD	Department of Defense
FCS	Future Combat Systems
GPS	Global Positioning System
HIMARS	High Mobility Artillery Rocket System
IOC	Initial Operational Capability
JDAM	Joint Direct Attack Munition
MDAP	Major defense acquisition program
PAUC	Program Acquisition Unit Cost
RDT&E	Research, development, test and evaluation
SAR	Selected Acquisition Report
SDB	Small Diameter Bomb
SM	STANDARD Missile

United States Government Accountability Office
Washington, DC 20548

May 6, 2010

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

For several decades, Congress and the Department of Defense (DOD) have been exploring ways to improve the acquisition of major weapon systems, yet poor program outcomes and their underlying causes have proven resistant to change. Last year, we reported that the cumulative cost growth in DOD's portfolio of 96 major defense acquisition programs was $296 billion from first estimates, and the average delay in delivering promised capabilities to the warfighter was 22 months.[1] However, in recent years Congress and DOD have made changes to policies which have led to improvements in some aspects of the acquisition process. For example, our 2010 assessment of major weapon system acquisition programs found that programs started since 2006 have higher levels of technology maturity when they begin system development.[2] More importantly, the opportunity to achieve widespread and meaningful improvements in weapon system programs may now be at hand, as both Congress and DOD have recently introduced major reforms to the defense acquisition process, including changes to: improve the department's ability to balance requirements with resources; establish a stronger foundation for starting programs; and execute programs more effectively. While these changes are promising, the challenge to achieving better program outcomes will be not only to ensure that they are consistently put into practice, but also to confront the environment in DOD that has made the weapon acquisition area resistant to reform.

In the Senate Armed Services Committee report for the 2006 National Defense Authorization Act, the committee directed us to review DOD's budget and requirements processes and assess how these processes can better support program stability in major weapon system acquisition. In

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[1]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-09-326SP (Washington, D.C.: March 30, 2009).

[2]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-10-388SP (Washington, D.C.: March 30, 2010).

response to this mandate, we have issued several reports that highlight weaknesses in these processes.[3] This report, the last in response to this mandate, identifies practices already present in the acquisition environment that are contributing to stable acquisition programs and yielding good outcomes. Lessons learned from successful weapon programs may provide additional guidance for programs implementing recent acquisition reforms. Specifically, we (1) identified and described programs within DOD's major weapon system acquisition program portfolio that were stable and on track to meet cost and schedule targets outlined at program development start; (2) determined what factors enabled some stable programs to achieve these cost and schedule targets; and (3) analyzed recent acquisition reform initiatives to determine how lessons learned from these stable programs can be of use as DOD implements acquisition reform.

To conduct our work, we identified stable programs in DOD's portfolio of major weapon system acquisition programs by analyzing data from the December 2007 Selected Acquisition Reports (SAR), the most recent full reports issued by DOD as of the time we conducted our work, as well as other program data.[4] We determined each program's growth in development cost, unit cost, and schedule from its original program baseline estimate and categorized the program as "stable," "moderately

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[3]In March 2007, we reported that DOD lacks an effective, integrated approach to balancing its weapon system investments with available resources. In July 2008, we reported that a knowledge-based funding approach could improve major weapon system program outcomes. In September 2008, we reported that DOD's requirements determination process had not been effective in prioritizing joint capabilities. See GAO, *Best Practices: An Integrated Portfolio Management Approach to Weapon System Investments Could Improve DOD's Acquisition Outcomes*, GAO-07-388 (Washington, D.C.: March 30, 2007); *Defense Acquisitions: A Knowledge-Based Funding Approach Could Improve Major Weapon System Program Outcomes*, GAO-08-619 (Washington, D.C.: July 2, 2008); and *Defense Acquisitions: DOD's Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities*, GAO-08-1060 (Washington, D.C.: September 25, 2008).

[4]DOD did not issue complete Selected Acquisition Reports for its major defense acquisition programs in 2009, so program costs had not been updated since the December 2007 reports, as of the time we conducted our work.

unstable," or "highly unstable."[5] From among the more stable programs, and other programs identified as successful by acquisition experts, we selected the following five programs as case studies: the Army's High Mobility Artillery Rocket System (HIMARS); the Air Force's Joint Direct Attack Munition (JDAM) and Small Diameter Bomb (SDB); and the Navy's Poseidon Multi-Maritime Aircraft (P-8A) and STANDARD Missile-6 (SM-6). For each case study, we reviewed key documents, and interviewed past and present program officials to identify key factors contributing to the program's stability. We also leveraged prior GAO work where we had identified enablers of stability in other programs, such as the Navy's F/A-18E/F Super Hornet and the Air Force's F-16 Fighting Falcon, as well as causes of instability in unstable programs, such as the Air Force's F-22 Raptor and Global Hawk programs. We reviewed recent legislative and policy changes relating to defense acquisitions. More information about our scope and methodology is provided in appendix I. We conducted this performance audit from November 2008 to May 2010, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Over the last several years, our work has highlighted a number of underlying systemic causes for cost growth and schedule delays in weapon programs. At the strategic level, DOD's processes for identifying warfighter needs, allocating resources, and managing acquisitions, which together define its weapon system investment strategy, do not work together effectively. As a result, the department often fails to balance the competing needs of the warfighter and commits to more programs than available resources can support. At the program level, DOD's culture and

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[5]We classified programs as "stable," "moderately unstable," or "highly unstable" based on growth in research, development, test and evaluation (RDT&E) and program acquisition unit cost (PAUC) estimates, as well as schedule slip, from their Milestone B estimates. Programs were assessed based on whether their RDT&E growth was less than 10 percent, between 10 and 35 percent, or 35 percent or more; whether their PAUC growth was less than 10 percent, between 10 and 30 percent, or 30 percent or more; and whether their initial capability schedule slip was less than 6 months, between 6 and 12 months, or 12 months or longer. We classified a program as stable if it was below the lowest threshold in at least two of our cost and schedule measures and no higher than the middle threshold range in the third measure.

environment often allow programs to start with too many unknowns. In other words, programs enter the acquisition process without a full understanding of requirements; with cost and schedule estimates based on overly optimistic assumptions; and with insufficient knowledge about technology, design, and manufacturing.

Prior GAO work in best practices has emphasized the importance of having a sound business case when starting major defense programs. The business case in its simplest form is demonstrated evidence that (1) the identified needs are real and necessary and can best be met with the chosen weapon system concept and (2) the chosen concept can be developed and produced within existing resources—funding, time, technologies, and people. In the DOD weapon system acquisition environment, a business case is typically established at Milestone B when significant resources are committed. Programs are then measured against the business case established at Milestone B.

A primary reason for cost and schedule problems is the encouragement within the acquisition environment of overly ambitious and lengthy product developments—sometimes referred to as "revolutionary" or "big bang" acquisition programs—that embody too many technical unknowns and insufficient knowledge about performance and production risks. The knowledge gaps are largely the result of a lack of early and disciplined systems engineering analysis of a weapon system's requirements prior to beginning system development which translates customer needs into a producible weapon system. If this early systems engineering is not performed, as has often been the case with DOD's major acquisitions in the past, significant cost increases can occur as the system's requirements become better understood by the government and contractor.

With high levels of uncertainty about requirements, technologies, and design, program cost estimates and their related funding needs are often understated, effectively setting programs up for cost and schedule growth. We recently assessed both service and independent cost estimates for 20 major weapon system programs and found that while the independent estimates were somewhat higher, both estimates were too low in most cases.[6] In some programs, cost estimates were off by billions of dollars. Estimates this inaccurate do not provide the necessary foundation for sufficient funding commitments. The programs we reviewed frequently

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[6]GAO-08-619.

lacked sufficient knowledge and detail to develop sound cost estimates. Without this knowledge, cost estimators may fail to adequately account for risk and uncertainty because they are relying on overly optimistic assumptions.

Recognizing the need for more discipline in weapon system acquisition, Congress and the department have been making changes to policies in recent years and we have seen improvements in performance across some aspects of the acquisition process. Most recently, the acquisition reforms that took place in 2009 indicate a desire on the part of Congress for improvement and willingness on the part of the department to change its culture and achieve better outcomes, and address some of the sources of instability that we have identified in our prior work.

Some 2008 Major Defense Acquisition Programs Appeared to Be on Track to Meet Their Original Cost and Schedule Projections

While our work has revealed significant aggregate cost and schedule growth in DOD's major defense acquisition program (MDAP) portfolio, individual programs within the portfolio vary greatly in the extent to which they experience cost and schedule growth. In our analysis of 63 individual programs and subprograms in DOD's 2008 MDAP portfolio, we found that 21 percent appeared to be stable and on track to meet original cost and schedule projections. These stable programs entailed relatively small investments and had shorter development cycles than programs reporting substantial cost growth and schedule slip. They were also significantly newer than less stable programs.

Approximately 21 percent, or 13, of the 63 MDAP programs that filed December 2007 SARs and were at least 3 years into development at the time[7] were stable, meaning they appeared to be on track to end close to

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[7]We excluded from our analysis 23 programs for which development cost, unit cost, or initial operational capability data were not available. We also excluded 9 MDAPs that were less than 3 years into development as of December 2007. We have previously found that a significant portion of cost increases often do not occur until after a program is approximately halfway through its development cycle. The average projected development cycle time for the programs in the 2008 MDAP portfolio was approximately 7 years. We therefore determined that including in our analysis programs that were less than 3 years into development might artificially overstate stability in the portfolio. Because we did not conduct any analysis of the excluded programs, we do not have any basis on which to comment upon the stability of the excluded programs.

the cost and schedule estimates established at development start.[8] These 13 programs are shown in table 1 below.

Table 1: Stable Programs

Program	Service	Development cost growth (percent)	Unit cost growth (percent)	Delay in initial capability (months)
Programs in Production as of December 2007				
EA-18G Growler electronic warfare aircraft	Navy	3.8	4.7	0
Minuteman III Propulsion Replacement Program	Air Force	-6.1	6.0	0
National Airspace System	Air Force	5.4	8.8	5
Small Diameter Bomb Increment I	Air Force	-4.9	-14.3	-1
Programs in Development as of December 2007				
AGM-88E Advanced Anti-Radiation Guide Missile	Navy	6.2	0.0	4
E-2D Advanced Hawkeye surveillance aircraft	Navy	5.8	9.6	0
Family of Advanced Beyond Line-of-Sight Terminals	Air Force	0.9	9.0	0
Mobile User Objective System	Navy	6.5	-1.2	6
Navy Multiband Terminals	Navy	-1.6	-4.8	0
P-8A Multi-mission Maritime Aircraft	Navy	-3.9	0.6	0
PATRIOT/Medium Extended Air Defense System Combined Aggregate Program Fire Unit	Army	-5.6	-4.4	0
PATRIOT/Medium Extended Air Defense System Combined Aggregate Program Missile	Army	-10.2	-3.3	0
STANDARD Missile-6	Navy	-7.7	-3.7	0

Source: GAO analysis of DOD data.

We assessed another 24 of these 63 programs as moderately unstable, and the remaining 26 as highly unstable.

The 13 programs that we assessed as stable tended to be smaller, representing just under 9 percent (or $103 billion in fiscal year 2009

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[8]While we attempted to account for our previous finding that cost increases often occur late in development by excluding younger programs from our analysis, it is likely that some programs that appeared stable according to this data may have since exhibited instability. For instance, the E-2D Advanced Hawkeye aircraft program, which appeared to be on track to meet original cost and schedule estimates as of December 2007 (54 months into its development), reported a critical cost breach in 2009.

dollars) of the total $1.15 trillion estimated total cost for these programs. (See fig. 1.)

Figure 1: Distribution of DOD Acquisition Programs by Number of Programs and Dollar Value

By number of programs
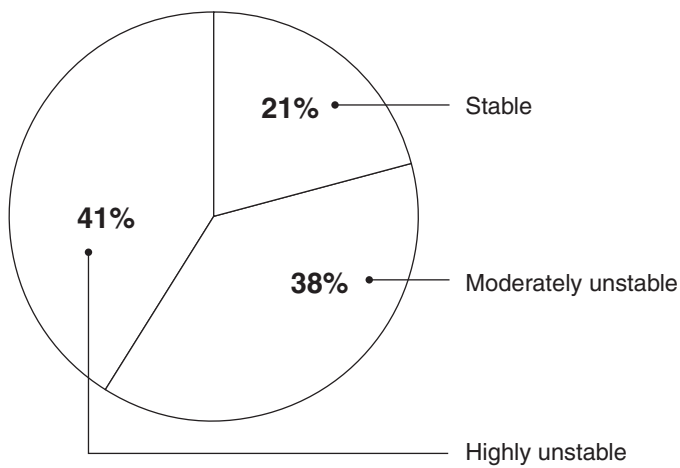
By dollar value of programs
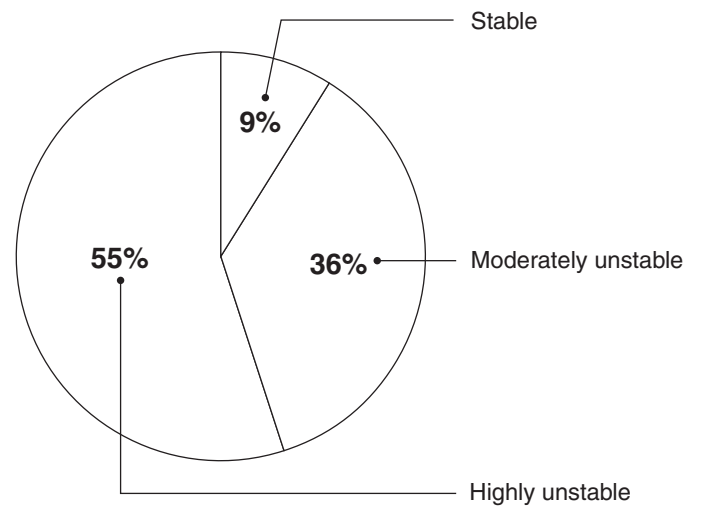
Source: GAO analysis of DOD data.

The average total program cost of the stable programs was $7.9 billion, while the averages were $17.2 billion and $24.5 billion for moderately and highly unstable programs, respectively.

Thirty-eight of the programs we analyzed had completed their development cycles and started production by December 2007. The four stable programs in this group tended to have shorter development cycles, on average more than 2 years shorter than the average for highly unstable programs. (See fig. 2.)

Figure 2: Average Length of Development Cycle for 36 Programs in Production (in months)

Average months in development
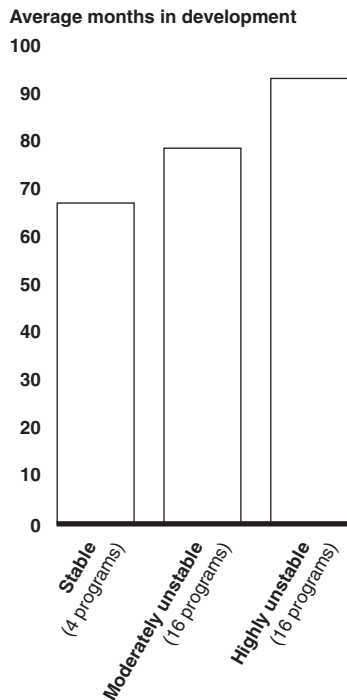
Source: GAO analysis of DOD data.

Note: This analysis excludes two satellite programs, because those acquisitions have been conducted under DOD's space acquisition process rather than its weapons acquisition process, and therefore the Milestone C dates listed for these programs are not necessarily indicative of the start of production, as they are for other programs.

The programs that we assessed as stable were also markedly newer than the less stable programs. Ten—or 77 percent—of the 13 stable programs had started development just 3 to 5 years prior to the December 2007 reporting date, compared to only 25 percent of the moderately unstable programs and 4 percent of the highly unstable ones that started in the same timeframe. (See fig. 3 for breakdown of stable programs' years since development start.)

Figure 3: Distribution of Stable Programs by Years Since Development Start

Number of programs

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12

10 |  ___
   | |   |
 8 | |   |
   | |   |
 6 | |   |
   | |   |
 4 | |   |
   | |   |                          ___
 2 | |   |                         |   |
   | |   |          ___            |   |
 0 |_|___|_____|___|_____|___|___
     3 to 5        5 to 10        10 or
                                   more
```

Years since Milestone B
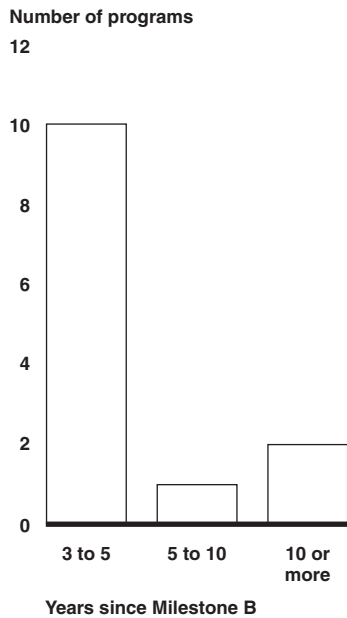
Source: GAO analysis of DOD data.

Stable Programs Had Strong Leadership Support, Disciplined Program Managers, and Executable Business Cases

The stable programs we studied had strong senior leadership support, disciplined program managers, and solid business plans which were well-executed. (Figure 4 presents a notional illustration of the relationship of these key factors.) These programs benefited from strong leadership support, in some cases because the programs were perceived as having an immediate need and, therefore, were viewed as a higher priority by senior leaders in the services and DOD. Their program managers tended to share key attributes such as experience, leadership continuity, and communication skills that facilitated open and honest decision making. As a result, these programs established sound, knowledge-based business plans before starting development and then executed those plans using disciplined approaches. They pursued incremental acquisition strategies, leveraged mature technologies, and established realistic cost and schedule estimates that accounted for risk. They were able to invest in early planning and systems engineering, and made trade-offs to close gaps between customer needs and available resources to arrive at a set of requirements that could be developed within cost and schedule targets. After approval, the programs resisted new requirements and maintained stable funding. These practices are in contrast to prevailing pressures in

DOD that force programs to compete for funds by exaggerating achievable capabilities, underestimating costs, and assuming optimistic delivery dates.

Figure 4: Key Factors That Enable Program Success
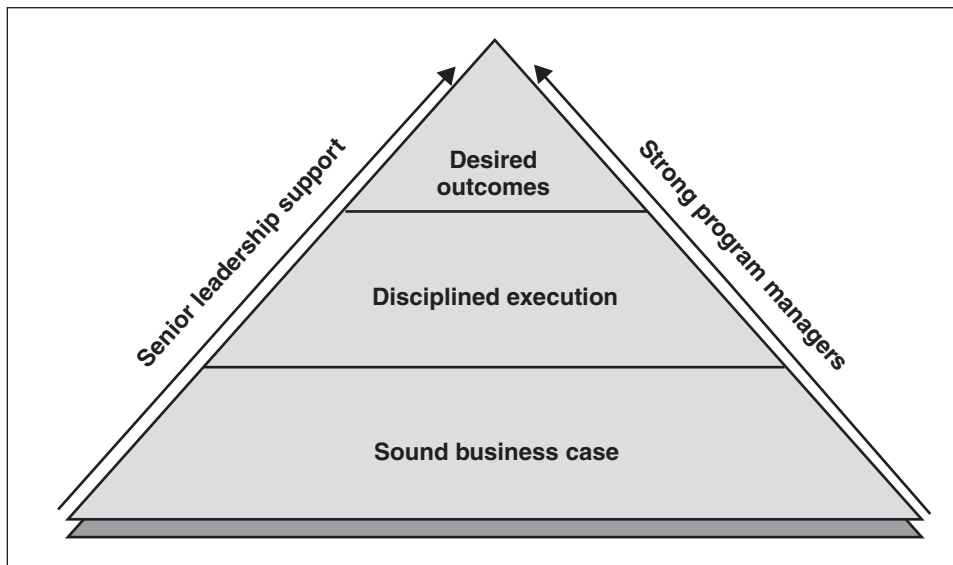
Source: GAO.

While we found 13 programs that were able to maintain stability and stay on track toward good outcomes, we focused in depth on the details of 5 programs to identify reasons for their success. These were the Air Force's Small Diameter Bomb and Joint Direct Attack Munition programs, the Navy's STANDARD Missile-6 and Poseidon Multi-Maritime Aircraft (P-8A) programs, and the Army's High Mobility Artillery Rocket System program.[9] Table 2 summarizes cost and schedule outcomes of each of our case study programs.

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[9]Three of our five case studies are among the 13 stable programs we identified; however, the other two had moderate cost and/or schedule growth but were selected because they had other attributes that were valuable to study. In particular, we selected JDAM as a case study because its unit costs were lower than originally estimated and it is widely recognized within the defense acquisition community as a successful program. HIMARS delivered capability on-time and it was one of the Army's most stable programs in the portfolio.

Table 2: Case Study Programs

Program	Service	Success indicators as of December 2007
Small Diameter Bomb (SDB) Increment 1	Air Force	SDB reduced development costs by almost 5 percent and unit costs by more than 14 percent, and made the system available one month earlier than anticipated.
Joint Direct Attack Munition (JDAM)	Air Force	JDAM reduced unit cost by 25 percent which, in part, enabled the Air Force to purchase more than twice the number of units originally expected.
STANDARD Missile-6 (SM-6) Extended Range Active Missile	Navy	The SM-6 program was on track to reduce expected development costs by more than 7 percent and unit costs by almost 4 percent, and expected to deliver initial capability on schedule.
P-8A Multi-mission Maritime Aircraft	Navy	P-8A was on track to reduce estimated development costs by almost 4 percent with less than 1 percent increase in unit cost and was scheduled to deliver initial capability on-time.
High Mobility Artillery Rocket System (HIMARS)	Army	HIMARS delivered initial capability on time in 2005. While development cost for the program grew about 20 percent from original estimates, this largely reflects a subsequent need to up-armor the vehicle in order to face new threats in the wars in Iraq and Afghanistan.

Source: GAO analysis of DOD data.

Strong Leadership Support and Unique Circumstances Were Key to Achieving Stable Programs

In the stable programs we studied, we found that strong, consistent support from DOD and service leadership fostered the planning and execution of solid business plans while helping program managers to adapt to the inevitable program perturbations. Program managers of stable and successful programs were able to make knowledge-based, disciplined decisions from the start and resist pressure to overreach or add requirements because of this strong institutional support. In some cases, high-level support may have been especially strong due to the particular circumstances of the programs, such as being designated as a high priority. For example:

- Early in the planning for SDB, the Air Force Chief of Staff established a clear written "Commander's Intent" stating that his priority was to have the weapon system available for use by the end of 2006. According to program officials, having this priority from the top was invaluable in helping the program establish and maintain an effective business plan for acquiring the system. For example, as the SDB operational requirements were going through the DOD requirements determination process, the Joint Staff attempted to add more requirements. In particular, the Army wanted SDB to have additional protections from nuclear attack; however, the program office got support from the user community, which, buttressed by support from the Office of the Secretary of Defense, managed to keep nuclear hardening from becoming a requirement by arguing effectively that it did not make sense for the weapon. In addition,

SDB was designated as the Air Force's highest priority program at Eglin Air Force Base, and program officials told us SDB was given preference for resources above all other programs on-base. Furthermore, SDB was designated as a "pathfinder program"—a group of programs established to pioneer ways to gain speed and credibility in acquisition.

- According to program officials, the termination of the STANDARD Missile-2 (SM-2) Block IVA program due to cost, schedule, and performance problems prompted the Navy to modify the next in its series of planned standard missile programs. Initially, the Navy proposed the STANDARD Missile-5 (SM-5) program, which was intended to develop sophisticated targeting capabilities. However, strong support from senior acquisition leaders allowed program officials to advocate for a more achievable and affordable "80 percent solution" which resulted in the SM-6 program. According to an early SM-6 program manager, the urgent need for a successful program helped set the stage for conducting thorough and detailed planning work prior to Milestone B. In addition, the program received strong support from the Assistant Secretary of the Navy for Research, Development and Acquisition in obtaining full funding for a realistic, risk-based cost estimate.

- According to an early program manager, although a mission need for HIMARS was identified in the early 1990s, the program was not started right away due to a lack of funding. However, prototypes of the system were developed through an Advanced Concept Technology Demonstration (ACTD) project—a DOD process to get new technologies that meet critical military needs into the hands of users faster and at less cost—and successfully demonstrated by the Army. This early program manager told us HIMARS had been dubbed "a 70 kilometer sniper rifle" by troops who have used the system in theater, because of its range and accuracy. Based on this success and the cancellation at the time of the Army's Crusader artillery program, HIMARS took on greater importance for the Army.

- JDAM was conceived of as a program that would integrate Global Positioning System (GPS) technologies into a precision strike guidance system. JDAM was designated as one of five high-profile programs to be executed under the Defense Acquisition Pilot Project, which gave JDAM the authority to implement certain acquisition reform provisions under the Federal Acquisition Streamlining Act of 1994 before they were published in regulation. According to studies of the JDAM program, advocates for the acquisition reform movement wanted quick, highly visible wins from these pilot programs to demonstrate the benefits of the legislation's strategy. JDAM program officials have stated that this sense of urgency and the increased flexibility provided to these pilot programs allowed officials to move quickly to achieve doable requirements. For instance, JDAM officials were able to streamline the program's milestone review process and reporting procedures. In addition, according to program

officials, the program allowed the contractor to maintain configuration control and use commercial products and make use of various commercial acquisition procedures that were uncommon at the time, with the goal of lowering costs. Also, the program was freed to structure innovative solutions such as a 20-year warranty included in the unit price. Furthermore, according to an early program manager for JDAM, the program was given very specific direction by the Air Force Chief of Staff to develop and produce the bomb at a low unit cost. This support allowed the program to make cost, schedule, and performance trade-offs and arrive at a solid business case for delivering the weapon system. According to the early program manager, one year into the program, a senior Air Force general pushed JDAM to accelerate its delivery schedule. However, when the program manager asked the general if this had been cleared with the Air Force Chief of Staff, the subject was dropped.

- The primary goal for the P-8A program was to replace the capabilities of the P-3C Orion, an aging Navy patrol aircraft that is very important to maritime security objectives, but is beginning to experience significant structural fatigue problems and must be replaced. According to program officials, this sense of immediacy has heightened the P-8A's priority and has forced the Navy leadership to set realistic requirements for quick delivery. However, an early program manager said that, rather than rushing into system development, the leadership permitted the program to conduct a detailed planning phase and establish a well-balanced package of cost, schedule and performance.

Beyond our case studies, we have also seen examples in the past where strong support from high level officials and unique circumstances contributed to program success. DOD acquisition officials, for example, noted that senior Navy leadership may have made the decision to pursue a cautious, more evolutionary approach for development of the F/A-18E/F Super Hornet tactical aircraft, in part because of (1) embarrassment over the much publicized failure of the A-12 stealth attack aircraft program which was terminated after considerable investment when the Navy determined that the contractor was unable to develop and deliver an aircraft that met requirements; and (2) diminishing capacity of the aircraft's previous generation—the F/A-18 C/D Hornet. In contrast, an official observed that the F-22 Raptor fighter aircraft program took a significantly more revolutionary, risky approach, likely due, in part, to the fact that the legacy F-15 Eagle fighter aircraft were still performing so well.

Stable Programs Had Strong Program Managers Who Shared Key Attributes

In addition to support from the top, program managers from successful programs tended to have similar attributes for success such as experience, leadership continuity, and communication skills that facilitated open and honest decision making. These program managers were empowered to make good decisions, allowing them to be accountable for the success or failure of the program. We found that successful managers took proactive measures to ensure the stability of their programs, including reaching out to stakeholders in the user and testing communities to facilitate their collaboration. For example, one program manager was described in a lessons learned memo developed by program officials as "part technical expert, part bulldog, and part diplomat. Steeped in the technical details of weapon development and aircraft integration, he sniffed out and pre-empted technical risks, made quick decisions, and aptly convinced stakeholders to support his positions."

Officials from our case study programs indicated that prior experience gives a program manager the knowledge to recognize and mitigate risks, and effectively respond to unanticipated problems that arise. For example, an early program manager for SM-6 told us that he and other key staff had been involved in the previous STANDARD Missile program (SM-2 Block IVA) that had been terminated. He explained that they were therefore very clear on what the potential problems were and were highly motivated to try to avoid them if possible. In addition, the current program manager of SM-6 said he has been in the STANDARD Missile program office since the mid-1980s and that he had worked in the program in various capacities before becoming program manager.

In addition, our case study programs experienced continuity of program management and other key staff that assisted knowledge-based decision making. We have previously reported that frequent program manager turnover may promote shortsightedness, challenge continuity, and reduce accountability for poor outcomes. In 2007, we reported that, for programs started since March 2001, the average program manager tenure was only 1.4 years.[10] In contrast, managers for our five case study programs served an average of 2.4 years. For instance, the SDB program had one program manager who served from before Milestone B through the low-rate production decision, providing leadership continuity for the entire system development phase. Also, many of our case study programs told us that

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[10]GAO, *Defense Acquisitions: Department of Defense Actions on Program Manager Empowerment and Accountability*, GAO-08-62R (Washington, D.C.: November 9, 2007).

other key staff, such as senior engineers, served many years in the program office and provided continuity and information necessary for knowledge-based decision making. JDAM officials also noted that the continuity of key civil service and contractor personnel has proven very beneficial because several other personnel have left the program due to military deployments and reassignments. Specifically, this included the chief engineer, who has been with the program from the beginning, and the director of production and delivery, who has been called upon to perform as the JDAM program manager to cover 6- to 9-month deployments of several past military program managers. Several support contractors also have been with the JDAM program for many years.

While the admission of program difficulties may be seen as detrimental to a program manager's career, leaders of our case study programs understood that direct and candid communication are essential to program success. Program officials observed that, by fostering a reputation for honesty and leadership, they were able to develop credibility with stakeholders, including contractors, and make compelling cases for what was needed. They emphasized the importance of including stakeholders early on in the process of solving problems so they are invested in the solutions being developed. For example, one early program manager for P-8A explained that his cooperative relationship with the requirements community enabled them to speak with a united voice about the need to keep requirements achievable. He described their approach as "starting slow to go fast" as opposed to the more common approach of "rushing to failure." In addition, he noted that candid communication and a welcoming attitude for scrutiny fostered top cover support from senior leadership in the Pentagon. Together, support from senior leadership and the requirements community for an extended concept development phase permitted the program to invest in success upfront, and this support carried throughout the execution of the program. Also, SDB officials explained that an early program manager proactively established collaborative relationships with organizations that the program relied on. For example, the program manager sought early buy-in from the testing community on the program's test and evaluation plans which helped facilitate keeping the testing schedule on track later on. The program office also cultivated very effective communication with its contractor, assigning program office representatives to work as facilitators with competing contractors during pre-Milestone-B prototyping work. Similarly, the SM-6 program manager said being on a first-name basis with the contractor vice-presidents helps him to manage the program effectively. SM-6 program officials also stated that the contractor program

manager meets weekly with staff to ensure the best possible talent is working on his program.

Stable Programs Established Sound, Knowledge-Based Business Plans at Program Start and Executed with Discipline

The stable programs we studied exhibited the key elements of a sound knowledge-based business plan at program development start. These programs pursued capabilities through evolutionary or incremental acquisition strategies, had clear and well-defined requirements, leveraged mature technologies and production techniques, and established realistic cost and schedule estimates that accounted for risk. They then executed their business plans in a disciplined manner, resisting pressures for new requirements and maintaining stable funding.

Stable Programs Had Achievable Increments Based on Well-Defined Requirements

The programs we reviewed typically took an evolutionary acquisition approach, addressing capability needs in achievable increments that were based on well-defined requirements. To determine what was achievable, the programs invested in systems engineering resources early on and generally worked closely with industry to ensure that requirements were clearly defined. Performing this up-front requirements analysis provided the knowledge for making trade-offs and resolving performance and resource gaps by either reducing the proposed requirements or deferring them to the future. The programs were also grounded in well-understood concepts of how the weapon systems would be used. For example:

- According to program officials, SDB was designed to meet a pressing Air Force need for a low-collateral-damage weapon which was small enough to maximize the number that can be carried aboard a single aircraft. Although the Air Force initially wanted SDB to have capability for hitting both fixed and mobile targets, a decision was made early on to defer the more difficult mobile target capability to a later program (SDB II). According to the Air Force's Deputy for Acquisition, the program worked early on with the warfighter community to focus on the "art of the possible," enabling them to proceed with an evolutionary acquisition approach. An analysis of alternatives was conducted which considered a broad range of alternatives and adequately assessed their risks. According to program officials, prior to Milestone B, the contractor submitted system performance specifications which were incorporated into the development contract. Once requirements were finalized at Milestone B, they were limited, and the program had a firm understanding of what compromises had been made and what capability has been deferred. Program officials told us they did not want to take on extra cost and schedule risk to try to achieve more than was possible.

- According to program officials, in planning the P-8A program, the Navy limited requirements to capabilities "as good as" those of the P-3C and deferred additional capabilities to later increments, adopting an "open architecture" approach to enable this acquisition strategy. The program also began with a robust analysis of alternatives which included a commercial derivative approach and helped the Navy recognize that an unmanned aircraft platform could perform some of the mission thus decreasing P-8A's requirements. The program received feedback from competing contractors on proposed requirements to make sure the requirements were well-understood before Milestone B. This feedback resulted in some requirement modifications before the award of the development contract.
- HIMARS was designed to be a wheeled version of a heavier tracked missile launcher—the M270—and lightweight enough to be transported on a C-130 aircraft. The design and requirements were well-understood and realistic from the outset, with rapid transportability of the platform a key goal and weight reduction a key challenge, according to program officials. Program officials also stated that there was a drive to use as much existing hardware as possible on the program, and maximize commonality with the most recent variant of the M270 launcher.
- The JDAM program was initially laid out in three phases to increase capabilities, including an adverse weather precision strike capability based on a need that was demonstrated during Operation Desert Storm. Phase I had clear, well-defined requirements—to add existing GPS technology to an existing inventory of "dumb" warheads. The final phase was based on technologies to be developed over time in the science and technology environment before they were integrated into the acquisition program. According to JDAM program officials, communication with the user community while they were in the planning phase allowed trade-offs which resulted in considerable cost avoidance. The program had an extensive user trade-off program during the initial requirements development in which the users and contractors adjusted their requirements and designs to accommodate each other. The program treated cost as a key performance parameter—the iterative planning process cut unit costs by more than half.
- SM-6 is the next generation in the STANDARD Missile program and has added extended range and active missile seeker homing capabilities for improved flight responsiveness and guidance over previous generations. According to program officials, it is designed to adapt to various threats, rather than designed to address a specific threat. The STANDARD Missile program has been developing ship-based air defense missiles for decades, so there was an established program office that invested time in pre-Milestone-B planning and coordination with stakeholders. According to program officials, the original plan for the next generation missile was a

more aggressive, costly solution dubbed SM-5. After thoroughly considering alternatives, however, the Navy decided to take the more cost conscious, incremental approach of the SM-6 which program officials said addressed 80 percent of their capability needs for half the cost of the SM-5.

Beyond our case studies, we have seen other successful programs in the past, including the F-16 Fighting Falcon fighter aircraft program, that also took more incremental acquisition approaches based on well-defined requirements. For instance, the F-16 program successfully evolved capabilities over the span of about 30 years. Using an evolutionary approach to develop the aircraft allowed the program to quickly deliver new and improved capabilities to the warfighter, and to increase the aircraft's capability as new technologies were matured and added to the aircraft. The first increment, developed during the 1970s, provided a "day fighter" aircraft with basic air-to-air and air-to-ground capabilities. This allowed the developer to deliver new and useful military capability to the warfighter in less than 4 years. With each subsequent increment, new technology was used to improve the engine, radar, structure, avionics, and other systems that allow the aircraft today to perform close air support, ground attack, air defense, and suppression of enemy defense missions. The evolutionary approach also enriched the industrial base capabilities by extending the life of the production over the length of this incremental approach.

In contrast, we have previously reported on many acquisition programs, including the Future Combat Systems (FCS), the F-22 aircraft, and Joint Tactical Radio System, that have proposed unrealistic and poorly understood requirements and pursued revolutionary, exotic system solutions which were ultimately extremely difficult or impossible to achieve. For example, the FCS program—which was comprised of 14 integrated weapon systems and an advanced information network—was to be the centerpiece of the Army's effort to transition to a lighter, more agile and capable combat force. However, the Army started this ambitious program in May 2003 before defining what the systems would be required to do and how they would interact. It did not expect to complete defining requirements until at least 2009, 6 years after program initiation. The program's failure to adequately define requirements early on resulted in design changes as well as significant cost and schedule growth. The FCS program has recently had elements cancelled and some of the remaining elements restructured into other programs.

Stable Programs Leveraged Mature Technologies and Production Techniques	The stable programs we reviewed also leveraged mature technologies and production techniques, anticipated system integration challenges, and demonstrated the feasibility of proposed weapon system concepts by completing prototypes before awarding development contracts. In these programs, the technologies typically needed to meet the essential system requirements had been demonstrated to work in relevant or realistic environments. Technologies that were immature generally either were not considered or were deferred to later program increments. Some of the programs also used established production lines, fostering stable production capabilities by limiting unknowns, achieving cost efficiencies, and accelerating the learning process necessary to develop effective production methods. Furthermore, these programs understood the challenge of integrating existing technologies, particularly of software items. Three of our five case study programs—HIMARS, JDAM, and SDB—developed prototypes before Milestone B, which allowed for the assessment of technologies, ensured that integration complexities were understood, and demonstrated the feasibility of the proposed system concept. For example:

- HIMARS's system feasibility was demonstrated through an ACTD project prior to Milestone B. According to an early program manager, although different technological solutions were utilized during formal system development, the early prototypes developed for this project proved that the system was feasible. In addition, HIMARS leveraged two technologies already in production: the chassis from the Family of Medium Tactical Vehicles program and the rocket pod from the Multiple Launch Rocket System.
- The P-8A airframe was developed from the Boeing 737 commercial aircraft, avoiding some time and risk inherent in developing a completely new airframe. In addition, according to program officials, the P-8A airframe is being produced on the same production line as the 737 which provides cost efficiencies and a decreased production learning curve. The program did not have fully mature technologies at development start, but identified existing technologies as back-ups. P-8A program officials also understood that software integration would likely be more complex than the contractor predicted and allocated resources accordingly.
- Previous iterations of the STANDARD Missile allowed significant maturity in the SM-6 program and, therefore, program officials said they focused development on integration and software challenges. SM-6 was designed based on the legacy STANDARD Missile airframe and propulsion systems and the Air Force's Advanced Medium Range Air-to-Air Missile active guidance system—both of which were also produced by Raytheon. According to program officials, this has allowed the program to use

existing technologies and to share production facilities, which has in turn produced cost efficiencies for the program.

- SDB's acquisition strategy was focused from the beginning on utilization of mature technologies. Program officials noted that, in their experience, SDB had an unprecedented level of design maturity and production readiness prior to Milestone B—the SDB guidance system, warhead, and link kit were all developed prior to program start. According to the Air Force's Deputy for Acquisition, SDB developed competitive prototypes, giving equal funding to two contractors with the goal of demonstrating maturity of their concepts prior to Milestone B. During source selection, contractors were only given credit for demonstrated performance of their prototypes—not for performance promised for the future. Program officials told us that this meant that the program entered the system development phase with production representative hardware that met the requirements—building more units, readying the factory for low rate production, and completing tests were the only jobs remaining for the then sole-source contractor. The program also conducted a critical design review with each contractor prior to Milestone B.
- Program officials told us that technologies for JDAM tail-kits were developed and demonstrated in a research environment several years before the program began. Similar to SDB, program officials told us that JDAM utilized competitive prototyping to develop and test proposed technologies. This allowed the program to incentivize contractors to achieve a prototype with a low unit cost prior to awarding the system development contract.

In contrast, we have previously reported that many programs rely on immature technologies and do not invest in prototypes before starting development. For instance, the Armed Reconnaissance Helicopter (ARH) failed in large part due to misunderstanding the level of development required to integrate a commercial solution. In addition, the F-22 was based on advanced technologies and experienced considerable problems during development due to a lack of an existing industrial and supplier base experienced in working with one another in fabricating, assembling and producing the high technology components necessary for the aircraft.

## Stable Programs Set Realistic Cost and Schedule Estimates

It is well recognized that realistic cost and schedule estimates that account for program risks are imperative to establishing a sound basis for acquiring new weapon systems. The foundation of a realistic estimate is a high degree of knowledge about program requirements, technology, design, and manufacturing. The stable programs we reviewed had realistic cost and schedule estimates at Milestone B because they had a good understanding of what was needed to develop and produce the proposed systems. Since Milestone B, our case study programs have generally

tracked to their initial development funding profiles. Specific examples of
good cost estimating and risk analysis from our case studies include

- The P-8A program was funded to an independent cost estimate which was
  about 14 percent higher than the service cost estimate. According to
  program officials, the independent cost estimators deemed the program's
  estimate for software development to be insufficient, and included
  additional funding in the cost estimate for this effort. After contract award,
  the Navy added $500 million to the contract to ensure adequate early effort
  for software development. The December 2007 development cost estimate
  was about 4 percent lower than the original 2004 estimate. (See fig. 5.)

Figure 5: Comparison of Original and 2007 Development Funding Estimates for P-8A

**Fiscal year 2004 dollars in millions**
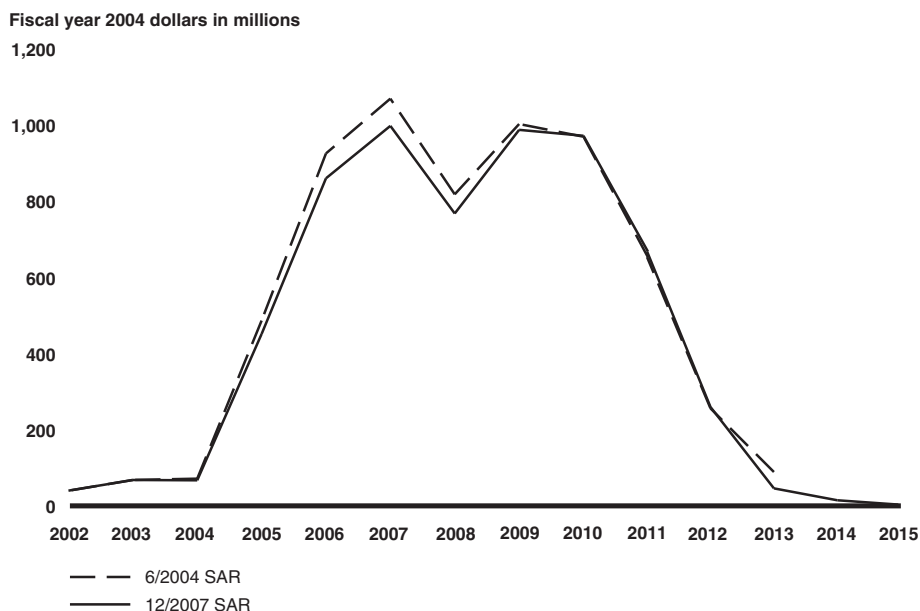
Source: DOD reported 2004 and 2007 SAR data.

- The SM-6 program also effectively estimated costs—according to an early
  program manager, the program insisted on including all related costs in its
  estimate, including field activity costs and the program's share of
  department-wide overhead and expenses. The program also allocated risk
  across the whole program, building in margin for each step. Because the
  program made a point to develop doable requirements, it had the
  prerequisite knowledge about technologies and design to make an
  accurate estimate and establish a realistic funding profile. (See fig. 6.)
  According to an early program manager, to realistically estimate schedule
  the program conducted a comparative study of major missile development

programs. From this study they concluded that all of these programs have taken between 9 and 12 years to get from Milestone B to initial capability. They used these historical numbers as the basis for the SM-6 schedule estimate.

Figure 6: Comparison of Original and 2007 Development Funding Estimates for SM-6

Fiscal year 2004 dollars in millions

- — 7/2004 SAR
- —— 12/2007 SAR
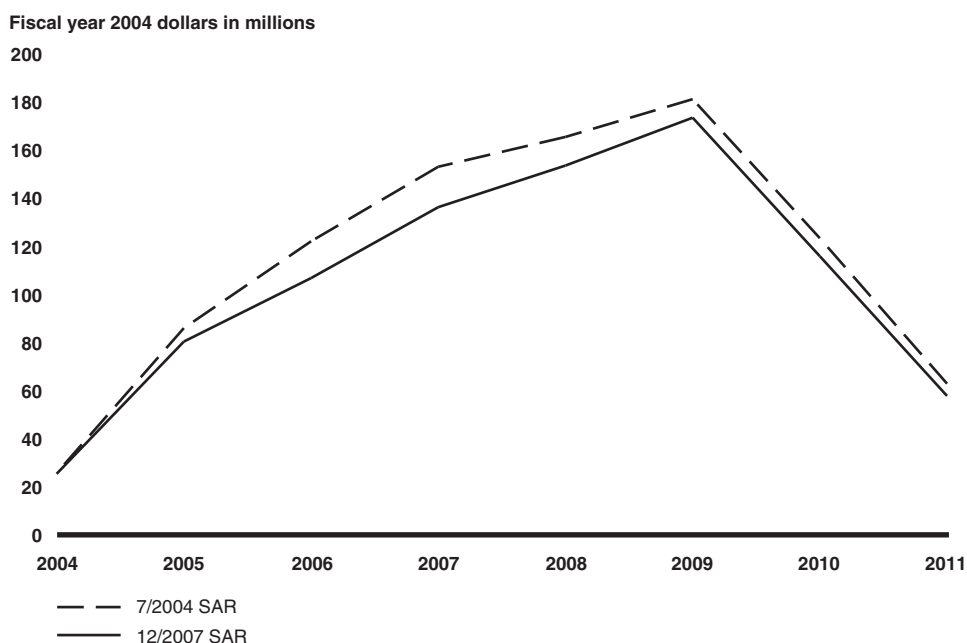
Source: DOD reported 2004 and 2007 SAR data.

Some of the stable programs we reviewed also included additional margin upfront for risky activities when constructing schedule estimates. A former P-8A program official stated that the program's development contract included 12 months of margin for risk; and a former SM-6 official said the program specifically included an assumption of two flight failures during testing—each entailing 2 to 3 months' time to address—explaining that no program realistically goes through all of its tests without a failure. In addition, this official told us that, instead of trying to eliminate risk by simply adding on a single schedule "cushion" at the end of the development cycle, they allocated schedule risk margin more strategically. First, the program identified the specific tasks that were sources of the greatest schedule risk and then they added a margin to the scheduled time allocated for each task. This decreased the chance that contractor personnel would be brought on board (and paid) to work on any specific

task prematurely, which in turn helped to decrease the cost consequences of schedule delays.

In contrast, others who began with overly optimistic cost and funding assumptions have required much more funding per year than first requested. For example, the Armed Reconnaissance Helicopter (ARH) program rushed through the planning process, skipping key systems engineering steps in a drive to obligate remaining funding from its predecessor program, the terminated Comanche reconnaissance helicopter. In 2009, we found that the analysis of alternatives for ARH looked at only two options—improvement of the existing system or procurement of nondevelopmental helicopters. We also found that the program did not adequately assess risk for these two alternatives.[11] According to program officials, the plan the program chose did not have room to trade-off cost, schedule, or performance. Schedule estimates were driven by a desired fielding date and cost was determined primarily by multiplying the desired unit cost by the number of desired aircraft. These cost and schedule requirements—which program officials said were directed by Army leadership—were developed without an understanding of the issues or a thorough vetting with relevant industry stakeholders. As a result, within 2 years of Milestone B, actual and estimated development costs had quickly escalated and the development schedule had been extended. Ultimately, it was determined that the strategy was not executable and the program was terminated in October 2008. Figure 7 shows the program's original funding estimate from 2005, based on a lack of knowledge about the weapon system's requirements and the resources it would take to deliver it, and its funding estimate prior to termination. We note that the estimated development funds required more than doubled—an increase of almost $365 million (fiscal year 2005 dollars)— and the development cycle time increased by 27 months between the program's start to December 2007.

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[11]GAO, *Defense Acquisitions: Many Analyses of Alternatives Have Not Provided a Robust Assessment of Weapon System Options*, GAO-09-665 (Washington, D.C.: September 24, 2009).

Figure 7: Comparison of Original and 2007 Development Funding Estimates for the ARH

Fiscal year 2005 dollars in millions

- - - 7/2005 SAR
——— 12/2007 SAR
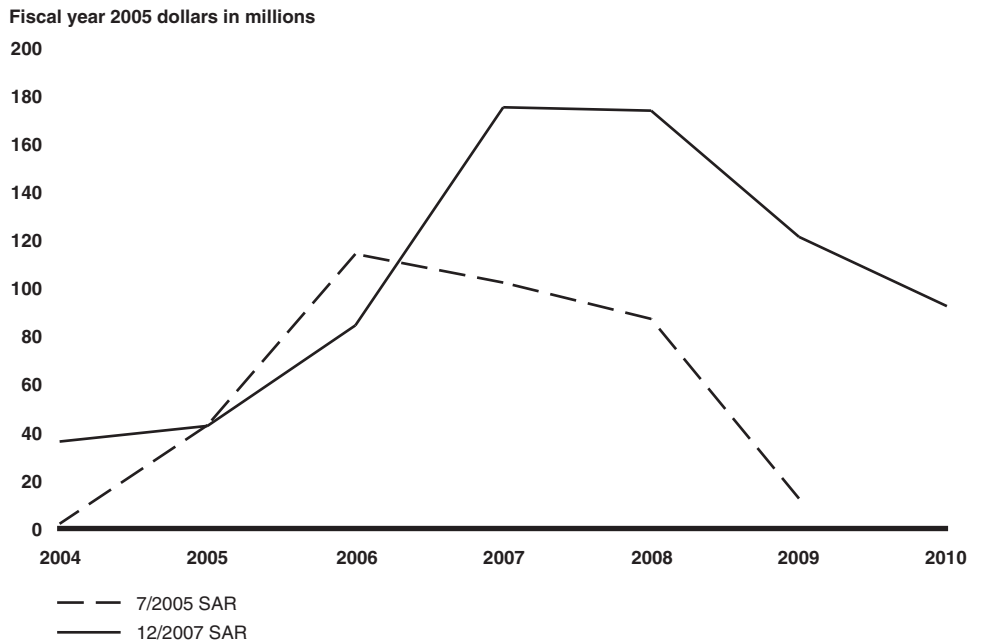
Source: DOD reported 2005 and 2007 SAR data.

The Air Force's Global Hawk unmanned aerial vehicle was approved for a simultaneous development start and low rate production in 2001. DOD restructured the Global Hawk acquisition strategy in March 2002 to include a second Global Hawk model. The program office estimated the cost, time, and funding required to develop this new, bigger model with more stringent requirements without a suffiicient understanding of the new model. It then restructured the program again in December 2002; changing the capabilities required in the new variant. As a result, the initial cost estimates had become outdated within 2 years of development start, and estimated total development costs had more than doubled. Figure 8 shows the program's original funding estimate from 2001 and its funding estimate as of December 2007. Estimated development funding has more than tripled and the development program has been extended by about 7 years.

Figure 8: Comparison of Original and 2007 Development Funding Estimates for Global Hawk

Fiscal year 2000 dollars in millions

- – – 3/2001 SAR
- —— 12/2007 SAR
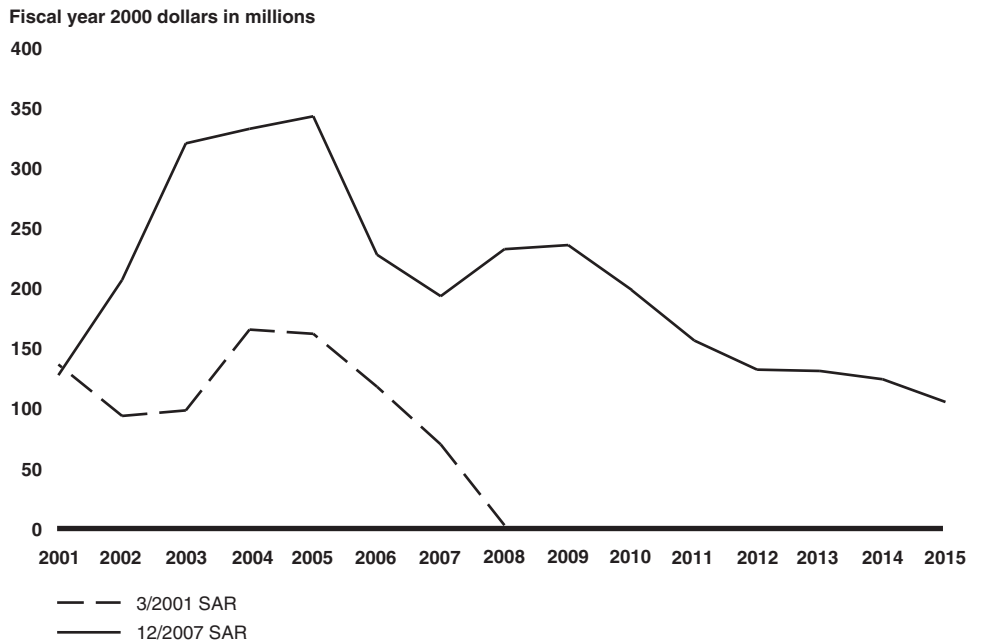
Source: DOD reported 2001 and 2007 SAR data.

Once Under Way, Programs Resisted Adding New Requirements

After starting development, our case study programs resisted adding new requirements by keeping stakeholders focused on the importance of adhering to cost and schedule, as well as performance commitments. For example, P-8A officials related that one reason for cost and schedule stability was the program office's willingness to limit capability and requirements changes proposed by the P-3C user community, and in particular, to find workable solutions to user-preferred "gadgets." For instance, to detect submarines, the P-3C used a technology that measured shifts in the earth's magnetic field. The user community insisted that P-8A use this technology, even though contractor engineers determined that it would require the development of very expensive software to account for differences in the airframes' structures. The P-8A program office successfully worked with the user community to gain acceptance of an alternative technology which provided the same submarine detection capability while keeping the program on cost.

In the JDAM program, some new requirements were added but according to program officials they did not alter the basic performance parameters of the program. One JDAM capability enhancement—a laser sensor—was

developed by the contractor with its own resources. In contrast, unstable programs sometimes chase performance, with less concern for cost implications. Global Hawk, for example, added new, major, and unplanned requirements after Milestone B, increasing cost and schedule significantly. Rather than establishing separate program increments, Global Hawk restructured its original program to add a new aircraft variant with enhanced capabilities.

Programs Maintained Stable Funding During Execution

In addition to starting with annual funding baselines based on realistic cost estimates, as discussed above, the stable programs we reviewed typically received annual development appropriations close to their full funding requests. For example, the P-8A program received 96 percent of its requested development funding for the years 2005 to 2007. (See fig. 9.)

Figure 9: P-8A Annual Development Funding Requested and Received

Dollars in then-year millions
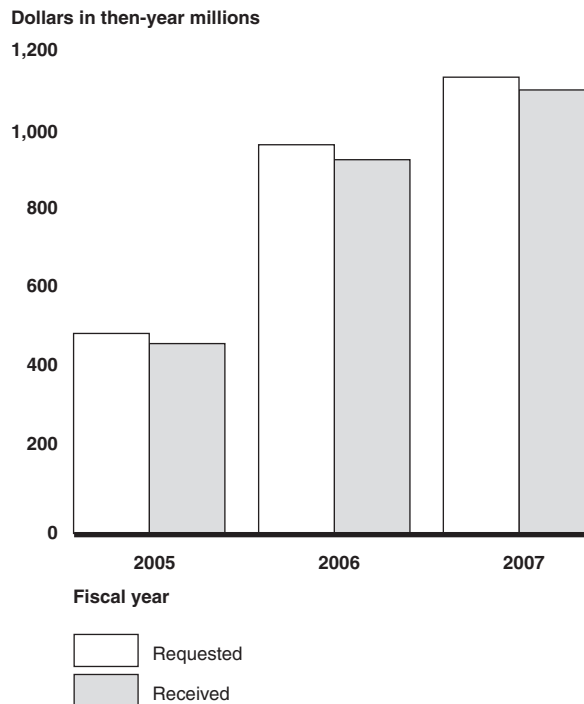
Source: Navy budget justification documents.

Although these data show the amount received in each year was slightly less than requested, P-8A program officials stated that overall the program has had very stable funding. They attributed the stability of funding to factors including (1) the acute need for the P-8A to be procured quickly and (2) the steady development of the aircraft accompanied by remaining

on track with initial cost and schedule goals from the outset of the program.

Officials from the other stable programs echoed these themes—particularly that good program execution inspired confidence in the program—when asked to explain relatively stable funding. In addition, HIMARS program officials told us they maintained good communication with their liaison to the funding community, ensuring that this liaison was fully informed of the status and progress of the program. They felt that this was extremely important, because a thorough and current knowledge of the program is what allows a liaison to advocate for the program and protect against cuts in funding. In addition, officials from the SM-6 program discussed proactively anticipating and responding to funding cuts. Program officials track what kind of funding cuts they could handle and what the effects might be. Program officials stated that when there is a request to take funding from the program, they always take the opportunity to respond and justify why the program cannot spare the money. Often that justification is accepted.

Funding stability is an essential ingredient to a successful program. However, in view of the many pressures that characterize the acquisition culture, stable funding and support alone will not prevent other acquisition problems, such as problems stemming from unrealistic performance requirements, immature technologies, and highly concurrent schedules. Funding instability has often been pointed to by program managers as a factor contributing to program instability. Given that there are too many programs for available resources and many programs encounter cost, schedule, and performance problems, it is not unexpected that some programs experience funding instability. However, we have also seen that funding instability can be the result, not the cause, of performance problems. For example, in 2002, we found that, while the F-22 program office attributed some of its production cost increases to a reduction in quantities, the program had been significantly affected by design and manufacturing problems that started during development.[12] For example, in 1997, an independent review team determined that the product development effort was underestimated. In short, successful programs enjoy funding stability, but funding stability does not ensure program success.

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[12]GAO, *Best Practices: Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002).

Recent Policy and Legislative Reform Initiatives Reflect Key Characteristics of Successful Programs

Recently, Congress and DOD have taken major steps towards reforming the defense acquisition system in ways that may increase the likelihood that weapon programs succeed in meeting planned cost and schedule objectives.[13] Many of these steps are consistent with key elements we found in our five stable case study programs. In particular, the new DOD policy and legislative provisions place greater emphasis on front-end planning and establishing sound business cases for starting programs. For example, the provisions strengthen systems engineering and cost estimating, and require early milestone reviews, prototyping, and preliminary designs. They are intended to enable programs to refine a weapon system concept and make cost, schedule, and performance trade-offs before significant commitments are made. Fundamentally, the provisions should help programs replace risk with knowledge, and set up more executable programs. Key DOD and legislative provisions compared with factors we identified in stable programs are summarized in table 3.

Table 3: Comparison of Factors Contributing to Stable Programs and Recent Acquisition Reform Initiatives

Stability factors	Recent acquisition reform initiatives
Establish a sound, executable business case	Overall, strong emphasis on front-end planning (pre-systems acquisition)
• incremental approach to acquiring capabilities	• incremental development emphasized, with each increment that provides a significant increase in capability to be managed separately
• clear, well defined requirements	• early reviews to be conducted prior to start of development (Milestone B) • enhanced requirements for Analysis of Alternatives • new leadership positions established to enhance systems engineering and developmental testing
• leverage mature technologies	• independent review of technology maturity and integration risk prior to Milestone B • competitive prototypes • Preliminary Design Review to be conducted earlier, prior to Milestone B

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[13]The Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23, was enacted May 22, 2009. In December 2008, DOD revised its acquisition instruction—Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System.

Stability factors	Recent acquisition reform initiatives
• establish realistic cost and schedule estimates	• new position and organization established to review and conduct independent cost estimates for MDAPs and provide cost estimating guidance DOD-wide
	• early cost estimate required for Milestone A
	• confidence level for cost estimates to be reported
Execute business case in disciplined manner	
• resist new requirements	• configuration steering boards established to stabilize requirements
	• post-Critical Design Review assessment required to review progress
• stable funding	

Source: GAO analysis of the Weapon Systems Acquisition Reform Act of 2009, Pub. L. No. 111-23, and Department of Defense Instruction 5000.02 (December 8, 2008).

While it is too soon to determine if Congress and DOD's reform efforts will improve weapon program outcomes, we have seen evidence that DOD is taking steps to implement the provisions. For example, in December 2009, the department issued a new implementation policy, which identifies roles and responsibilities and institutionalizes many of the requirements of the Weapon Systems Acquisition Reform Act of 2009. It has also filled several key leadership positions created by the legislation, including the Directors for Cost Analysis and Program Evaluation, Developmental Test & Evaluation, and Performance Assessments and Root Cause Analyses. To increase oversight, the department has embarked on a 5-year effort to increase the size of the acquisition workforce by up to 20,000 personnel in 2015. Furthermore, the department has begun applying the acquisition reform provisions to some new programs currently in the planning pipeline. For example, many of the pre-Milestone-B programs we reviewed this year as part of our annual assessment of selected weapon programs plan to develop competitive prototypes and conduct a preliminary design reviews before going to Milestone B.[14] In the Joint Air-to-Ground Missile program, the Army recently awarded two contracts for a 27-month technology development phase which will culminate in test flights of competing prototypes prior to Milestone B.

The success of DOD's efforts, however, will depend in part on how consistently the new provisions are implemented and reflected in

[14]GAO-10-388SP.

decisions on individual programs. In the past, inconsistent implementation of existing policy hindered DOD's ability to plan and execute programs effectively. Inconsistent implementation occurred in part because decision makers were not held accountable for programs outcomes and there were few, if any, consequences when programs ran into problems. Furthermore, cultural and environmental forces at DOD work against sound management practices. These forces encourage programs to pursue overly ambitious requirements and lengthy development efforts, and to move forward with risky and unexecutable acquisition strategies. We have found too often that program sponsors overpromise capabilities and underestimate costs in order to capture the funding needed to start and sustain development programs. For acquisition reforms to be effective, they will have to address these forces as well. For example, while acquisition reform provisions are intended to make cost estimates more reliable and realistic, the provisions may be compromised by the competition for funding that encourages programs to appear affordable when they are not. Furthermore, when program sponsors present a program as more than a weapon system, but rather as essential to new fighting concepts, pressures exist to accept less-than-rigorous cost estimates. If reform is to succeed, then programs that present realistic strategies and resource estimates must succeed in winning approval and funding, as was the case with the stable programs we reviewed. Those programs that continue past practices of pushing unexecutable business cases must be denied funding before they begin.

DOD will also need to ensure that adequate resources—funding and workforce capacity—are available to support the front-end planning activities now required for new weapon programs. In the past, budget realities within DOD have made it more advantageous to fund technology development in acquisition programs because most of the department's research and development funding goes to existing programs of record. Weapon system programs have historically received about 80 percent of the department's research and development budget whereas science and technology activities have received about 20 percent of the budget. The money going toward science and technology is spread over several thousand projects, while the money going toward weapon programs is spread out over considerably fewer projects. This "distribution of wealth" makes it easier to finance technology development within an acquisition program. Once initiated, a program is in a more competitive position to attract funding support from within the department. With competition for funding intense, due to the high demand for weapon systems and other needs in the department, freeing up funds for pre-systems acquisition activities may be challenging. Yet, as we have seen in stable programs,

strong leadership support ensured that there was sufficient funding and other resources to effectively plan up front.

Because programs in the past tended to proceed to Milestone B too quickly, there may be limited experience in DOD in conducting many of the program planning activities now required by the acquisition reform initiatives. Lessons learned from stable programs, such as the case study programs we reviewed, could serve as useful tools for the successful implementation of the reform initiatives. For example, these programs had the following: effective and consistent leadership in place early on; program managers who were empowered to plan and establish a sound business case for starting a program; resources available for conducting front-end systems engineering and planning; established mechanisms to engage industry early on and to contract for prototypes; flexibility to make cost, schedule and performance trade-offs before committing to a business case; cost and schedule baselines that realistically accounted for risks; and evolutionary acquisition approaches that address capability needs in achievable increments based on well-defined requirements.

Conclusions

Although most DOD programs fail to meet their intended cost and schedule objectives, some programs have still been successful. No one factor will ensure success; instead, a lot of things need to go right in both planning and implementing a program. However, it is critical to get the systems engineering and planning phase right, because extraordinary implementation cannot save a program with a business case that was flawed from the beginning. In our case studies, we found that stable programs established sound, knowledge-based business cases before moving forward and then executed them in a disciplined manner. How they were able to successfully do this was largely due to strong leadership support and proactive program managers who knew how to get results. Getting the right people in place at the right time and supporting them with the requisite resources is critical. However, programs are also more likely to succeed when there is a sense of urgency to deliver a needed capability and senior leadership views the program as a high priority. In addition, programs benefit from having experienced program managers who provide consistent leadership through major phases of a program.

Relying on strong leadership or treating each program as a priority is not scalable across DOD's broad portfolio of weapon programs. Rather, good program outcomes ought to occur normally as an outgrowth of effective policy, processes, priorities, oversight, and leadership. Acquisition policy and processes establish rules and mechanisms that facilitate good

program decisions. However, rules and mechanisms are only as good as the people that implement them. The new round of DOD and Congressional acquisition reforms create a renewed opportunity to improve acquisition outcomes, but only if it is accompanied with the appropriate leadership support that allowed the stable programs we reviewed to establish reasonable business cases and execute them with confidence. If reform is to succeed, programs that present realistic strategies and resource estimates must succeed in winning approval and funding. Those programs that continue past practices of pushing unexecutable strategies must be denied funding before they begin.

Agency Comments and Our Evaluation

In written comments on a draft of this report, DOD stated that it was encouraged that the report cites progress made over the past several years to improve acquisition processes and reduce cost and schedule growth. DOD's response is reprinted in appendix II. DOD noted that it has recently instituted several major changes to acquisition policy that are aimed at starting programs right by using early planning and systems engineering, joint analysis teams, competitive prototyping, configuration steering boards, credible cost estimates, and program manager service agreements. DOD anticipates improvements in program performance in the ensuing years due to the recent acquisition reform initiatives.

DOD agreed with the reasons we found for program success, such as strong leadership, disciplined program managers, executable business cases, and achievable increments based on well-defined requirements. However, DOD pointed out that our findings are based upon small, less costly, and less complicated programs which may not be readily scalable to large, software intensive systems such as satellites or the Joint Strike Fighter. While we agree that more complex weapon system programs present greater challenges, we have previously reported that DOD should consider increasing the number of programs which provide incremental improvements in capability to the warfighter in a timely way. Complex programs that we cite in our report, such as the F/A-18E/F and the F-16, were able to balance requirements with available resources and produce cutting-edge weapon systems within cost and schedule targets. Revolutionary efforts that rely on unproven technological breakthroughs should be the exception rather than the rule. In addition, regardless of program complexity, the decision to begin a weapon program should be knowledge-based and decision makers need to be fully informed of the risks and scope of the effort to be undertaken. In the past, the decisions to enter into revolutionary acquisition programs such as the Joint Strike Fighter were based on overly optimistic assumptions of the cost and time involved to acquire these systems.

DOD also noted that although the measures we used to measure program performance are useful—change in development cost, unit cost, and schedule from the original program baseline—they are only valid when operational requirements remain static throughout the program lifecycle. According to DOD, in some cases, the warfighter's needs change and the department must adapt by enhancing weapon system functionality. We agree that the needs of the warfighter are paramount; however, DOD would be in a better position to adapt to the changing needs of the warfighter by reducing the time it takes to field new systems and enhancing weapon system functionality in future increments. According to DOD acquisition policy, incremental development is the preferred approach and each increment that provides a significant increase in capability should be managed separately.

DOD agreed that program manager tenure is a contributing factor in program stability, but thought that our characterization of tenure as an average is misleading because it does not reflect the total time program managers serve in their positions. The baseline average we calculated is based on data collected as part of our 2007 report on program manager empowerment and accountability.[15] Our work has shown that rather than having lengthy assignment periods between key milestones as suggested by best practices, many programs we have reviewed had multiple program managers within the same milestone. Furthermore, the key point we are making in the report is that program manager tenure in our case study programs, calculated using the same methodology used in our previous report, was longer than what we have seen in other programs (2.4 versus 1.4 years), which was a contributing factor to their relative success.

DOD also questioned our criteria for defining "stable" and "unstable" programs and thought that our evaluation criteria were subjective and should have been based on accepted standards, legislation, and regulations. However, aside from the Nunn-McCurdy breach criteria established by Congress for "significant" and "critical" unit cost growth in major weapon programs—30 and 50 percent growth respectively from the original baseline—there are no standard criteria established for assessing weapon program stability. We are not suggesting that the criteria used in our report is the only way to measure program stability; however, we believe it is important to examine programs from several perspectives—growth in development and unit costs, and delay in achieving initial
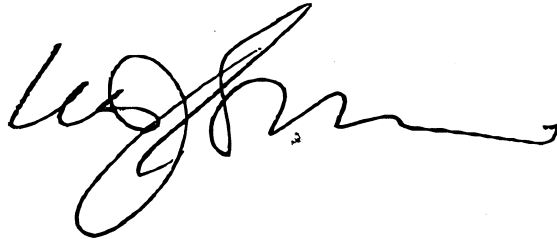
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[15]GAO-08-62R.

operational capability. We selected thresholds for these three indicators based on historical cost and schedule growth in major defense acquisition programs and our judgment based on many years of conducting DOD program reviews.

DOD also provided technical comments which we incorporated where appropriate.

We are sending copies of this report to the Secretary of Defense and interested congressional committees. In addition, this 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 about this report or need additional information, please contact me at (202) 512-4841 or sullivanm@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix III.

Michael J. Sullivan, Director
Acquisition and Sourcing Management

Appendix I: Objectives, Scope, and Methodology

This report identifies and examines some major defense acquisition programs that have stayed relatively close to the cost and schedule estimates established when they started development, in order to identify useful lessons that can be implemented with the current acquisition reforms. Specifically, our objectives were to (1) identify and describe programs within the Department of Defense's (DOD) 2008 major weapon system acquisition program portfolio that were stable and on track to meet cost and schedule targets outlined at program development start; (2) determine what factors enabled some stable programs to achieve these cost and schedule targets; and (3) analyze recent acquisition reform initiatives to determine how lessons learned from these stable programs can be of use as DOD implements acquisition reform.

To identify and describe programs that were stable, we analyzed data from DOD's Selected Acquisition Reports (SAR), as well as other program data. DOD typically submits SARs on current major defense acquisition programs to Congress at the end of the first quarter of each fiscal year, which provide a basis to determine each program's cost and schedule performance. We first obtained the list of the programs that published SARs in December 2007 (the last year in which full SARs were published, as of the time we conducted our work) from the December 2007 SAR summary tables posted on DOD's public acquisition Web site. We excluded programs for which December 2007 was the first SAR or the termination SAR, as we could not make valid baseline comparisons for these programs. We also made other minor adjustments to the program list to enable valid baseline comparisons, such as separating subprograms that were listed as one in the 2007 SAR table but reported the relevant data separately. We were left with a list of 95 programs, for which we obtained SAR data and other information through the Defense Acquisition Management Information Retrieval (DAMIR) Purview system.[1] We also analyzed data submitted to us by program offices as part of our annual review of selected weapon systems. We then excluded from our analysis programs for which not all data necessary for our baseline comparisons

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[1]DAMIR Purview is an executive information system operated by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics / Acquisition Resources and Analysis.

were published, as well as those which passed Milestone B less than 3 years prior to the December 2007 SAR report.[2]

We analyzed each of the remaining 63 programs based on data we obtained from DAMIR and from program offices. We retrieved data from each program's original development baseline report that showed estimated total amount of research, development, test, and evaluation (RDT&E) costs, total program acquisition unit costs (PAUC), and date of initial operational capability for the program, as of the start of development. We then obtained comparable data on each program from its December 2007 SAR. We converted all cost information to fiscal year 2009 dollars using conversion factors from the DOD Comptroller's National Defense Budget Estimates for Fiscal Year 2009 (Table 5-9). Through discussions with DOD officials responsible for the DAMIR database and confirming selected data with program offices, we had previously determined that the SAR data and the information retrieved from DAMIR were sufficiently reliable for our purposes.

Using these data, we assessed program stability for each program as described below. We defined "program stability" to mean minimal change from first full cost and schedule estimates to the December 2007 estimates. Because it was not feasible to compare original baseline versus current program performance on all relevant parameters, we chose three that best provided an indication of whether a program had remained close to its cost and schedule estimates. These three stability indicators included:

A. Total RDT&E (or "development") costs: This metric represents the estimated cost of developing a system from the beginning of development to the point at which it is ready for low-rate production.

B. Program Acquisition Unit Costs (PAUC): This measure represents the expected acquisition cost for each unit procured, as determined by dividing the sum of a program's estimated total program development, procurement, and military construction costs by the number of units to be procured.

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[2]We started with 95 programs, then excluded 23 programs for which we were lacking data on development costs, unit costs, or initial operational capability (IOC) date. We then excluded nine programs that had started development less than 3 years ago.

C. Initial Operational Capability (IOC) or equivalent date: IOC is generally achieved when some units or organizations that are scheduled to receive a system have received it and have the ability to employ and maintain it. Where programs did not report expected IOC dates, we substituted equivalent dates such as "First Unit Equipped" or "Required Assets Available" dates reported.

We compared each program's initial estimate for each of these three indicators with the actual/estimated values reported in its December 2007 SAR. We assigned a point score for change on each indicator based on the following thresholds:[3]

A. Development (RDT&E) cost growth:

- Programs that reported less than 10 percent development cost growth received 10 points.
- Programs that reported at least 10 percent, but less than 35 percent estimated development cost growth received 5 points.
- Programs that reported at least 35 percent development cost growth received 0 points.

B. Expected unit cost (PAUC) growth:

- Programs that reported less than 10 percent growth in expected unit costs received 10 points.
- Programs that reported at least 10 percent, but less than 30 percent growth in expected unit costs received 5 points.
- Programs that reported at least 30 percent growth in expected unit costs received 0 points.

C. Expected initial capability schedule slip:

- Programs that reported less than 6 months slip in expected IOC date received 10 points.
- Programs that reported at least 6 months, but less than 12 months slip in expected IOC date received 5 points.

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[3]These thresholds were determined through a consideration of criteria such as thresholds for required reporting of cost and schedule growth under law and regulation, historical average cost growth for weapons systems programs, and judgment based on GAO experience. These thresholds were not intended to directly represent any thresholds for allowable cost growth under law or DOD regulation.

- Programs that reported at least 12 months slip in expected IOC date received 0 points.

We summed the scores for each program across the three indicators, to arrive at a total point score representing our assessment of the program's overall stability. We categorized each program as "stable," "moderately unstable," or "highly unstable" as described in table 4.

Table 4: Point Scores for Stability Assessment

Total point score	GAO assessment of stability
25 or 30 points	Stable
10, 15, or 20 points	Moderately unstable
0 or 5 points	Highly unstable

Source: GAO.

We then analyzed the distribution of stable, moderately unstable, and highly unstable programs, examining number of programs, average program cost, and total acquisition dollar value (current estimates) represented by programs in each category. We also summarized the distribution of programs by age (measured as years into development) among stable, moderately unstable, and highly unstable programs. Finally, based on programs' reported Milestone B and C dates, we reported development cycle time data for a subset of our programs. We limited this inquiry to those programs that had entered production, so that data on actual development cycle time was available. We excluded ship and satellite systems from this analysis, as system development start and end points are defined differently for these systems.

To more closely examine factors that enhance program stability, we chose a selection of five example programs for in-depth study. We identified case study programs based on data from a variety of sources, including our analysis of programs in the 2008 MDAP portfolio, our review of the literature on weapons system acquisitions, including work conducted by RAND and the Defense Acquisition University, and prior GAO work on programs that have demonstrated best practice approaches. We also interviewed defense acquisition experts to learn which programs are seen as role models among acquisition programs. We selected the five case study examples using a criteria-based, nongeneralizable sample in order to achieve representation across the military services as well as a variety of weapon platforms. The following five programs were selected as case studies: the Army's High Mobility Artillery Rocket System; the Air Force's Joint Direct Attack Munition and Small Diameter Bomb; and the Navy's

Poseidon Multi-Maritime Aircraft (P-8A) and STANDARD Missile-6. For
each case study, we reviewed key documents, information from program
offices on program managers, and interviewed past and present program
officials to identify key factors contributing to the program's stability. We
also met with former senior DOD acquisition officials to further
understand factors that stabilize programs. In addition, we met with
program officials and reviewed prior GAO work on the Air Force's F-22
Raptor and Global Hawk programs to better understand the factors which
influenced these unstable programs. We also reviewed prior GAO work
where we had identified enablers of stability in other programs, including
the Navy's F/A-18E/F Super Hornet and the Air Force's F-16 Fighting
Falcon. To assess information about programs' cost estimates, we
compared original development funding estimates from programs'
baseline SARs to development funding estimates from the most recent
December 2007 SARs. In addition, to illustrate funding stability for the P-
8A program, we compared requested and received budget amounts from
budget justification documents.

To determine how lessons learned from stable programs can be of use as
DOD implements acquisition reform, we reviewed recent legislative and
policy changes relating to defense acquisitions and compared these
initiatives to our findings regarding the factors that enable program
stability.

We conducted this performance audit from November 2008 to May 2010, in
accordance with generally accepted government auditing standards. Those
standards require that we plan and perform the audit to obtain sufficient,
appropriate evidence to provide a reasonable basis for our findings 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: Comments from the Department of Defense

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

ACQUISITION,
TECHNOLOGY
AND LOGISTICS

APR 30 2010

Mr. Michael J. Sullivan
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Sullivan:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-10-522, "DEFENSE ACQUISITIONS: Strong Leadership is Key to Planning and Executing Stable Weapon Programs," dated March 23, 2010 (GAO Code 120794).

The Department is encouraged that the draft report cites the progress we have made over the past several years in our efforts to improve acquisition processes and reduce cost and schedule growth. We are proud that many of our acquisition programs are performing well, and we appreciate that the GAO has formally recognized several of them. We have instituted several major changes that are beginning to show results. As noted in the draft report, recent acquisition policy revisions and the Weapon Systems Acquisition Reform Act (WSARA) of 2009 are aimed at starting programs out right by using early planning and systems engineering, joint analysis teams, competitive prototyping, configuration steering boards, credible cost estimates, and program manager service agreements. In the ensuing years, we anticipate improvements in program performance measures due to our recent acquisition reform initiatives. While the draft report does recognize the gains due to the Department's initiatives, the full breadth of those benefits were not emphasized in the text.

The Department agrees with the reasons for program success, such as strong leadership, disciplined program managers, executable business cases, and achievable increments based on well-defined requirements. While many of the insights in the draft report are informative, they are based upon small, less costly and less complicated programs and may not readily scale to large, software intensive systems such as satellites, the Joint Strike Fighter, or other highly complex weapon systems. Moreover, many of the programs are being penalized for carrying cost growth and schedule slips that occurred many years ago, their original program cost and schedule estimates are very old and were overly optimistic. The Department can now report that these programs have turned the corner and are now stable and performing well.
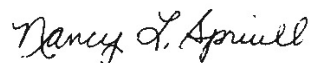
The Department agrees that the use of development cost, unit cost and delay in IOC are useful measures of program performance; however, they alone are not the only measures of stability. The draft report defines stable and unstable programs not in terms of historical outcomes, but rather as whether programs "are relatively on-track to meet cost and schedule targets as defined at program development start." This definition is valid when operational requirements remain static throughout the program lifecycle. In some cases, the Warfighter's needs change through time, and DoD has an obligation to provide the best weapon systems to achieve U.S. military objectives. The Department owes it to the nation to be able to adapt to a changing international threat environment. This strategic agility and its associated enhanced system functionality do impact cost and schedule. Managing programs on the cutting edge of science, technology, and engineering does carry risk with it. For these reasons, it is not always useful to assess acquisition programs relative to the initial conditions at program inception.

I thank you and your staff for working with the Department to improve the information flow between our organizations and to develop more meaningful metrics in this area. I look forward to continuing to improve the acquisition process to more effectively and efficiently deliver products to our customers, and we need to continue to develop better metrics. The Department looks forward to working with the GAO in both of these important endeavors.

The Department appreciates the opportunity to comment on the draft report. Additional comments are provided as an enclosure to this letter. My point of contact for this effort is Mr. Joseph Alfano, 703-697-3343.

Sincerely,

Dr. Nancy L. Spruill
Director,
Acquisition Resources & Analysis

Enclosure:
As stated

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ENCLOSURE

**GAO DRAFT REPORT DATED MARCH 23, 2010
GAO-10-522 (GAO CODE 120794)**

**"DEFENSE ACQUISITIONS:
STRONG LEADERSHIP IS KEY TO PLANNING AND EXECUTING STABLE
WEAPON PROGRAMS"**

**DEPARTMENT OF DEFENSE COMMENTS
ON THE DRAFT REPORT**

Applications of Lessons Learned

- The draft report does not emphasize recent initiatives that the Department undertook to enhance program acquisition management. For instance, page 4 of the draft report states "...programs enter the acquisition process without a full understanding of requirements..." which reflects the "sins of the past." The programs that failed to properly understand requirements were among the oldest in the portfolio. The Department has since placed a much greater emphasis on managing requirements. Additionally, given the uncertain and evolving military threats that confront our nation, such a high standard for requirements may be unachievable. Because the nature of the threats is not static throughout the life of a weapon system, neither are the program requirements. The Department agrees that resisting new requirements is important, and we have implemented configuration steering boards to manage requirements growth; however, the Department must also be responsive to the Warfighters' future needs.

- The draft report implies that PM tenure is a significant factor in program stability. The Department agrees that while it is a contributing factor, characterizing PM tenure as an average is misleading. Specifically, on page 16, the draft report states that the average program manager (PM) tenure is 1.4 years. By design, PMs serve in their positions for three years, so at any point in time the population of PMs should be half-way through their three year tenure: statistically 1.5 years. The draft report implies that this "snapshot in time" average PM tenure of 1.4 years represents the total time PMs serve in their positions. Since the full tenure period for a PM is three years, this is clearly not the case. Since this is not the first time we have disagreed on this statistic, I would offer to collaborate with you to sample the PMs and have a shared database from which to work.

Assessment of Programs vis-à-vis cost and schedule growth

- The evaluation criteria are subjective. Page 3 of the draft report contains the evaluation criteria and concedes that the criteria are not traceable to legislation or

Enclosure

regulations used to report cost and schedule growth. The draft report's evaluation criteria are *ad hoc* and internally inconsistent: the upper cut-off for RDT&E cost growth is 35%, while the equivalent threshold for program acquisition unit cost (PAUC) growth is 30%. When the study's criteria are applied to the five programs identified as exemplars, two of them (HIMARS and JDAM) do not rank as stable programs.

- The study used nonstandard cost and schedule data. The Objectives, Scope and Methodology section states that "other program data" supported the study. The Department has been unable to reproduce the study results using Selected Acquisition Report (SAR) data.

- The Department recommends using evaluation criteria based on accepted standards, legislation, and regulations. The table below relates the DoD growth parameters to enacted legislation. For IOC slip, the cutoffs are 12 months and 24 months total growth beginning with the IOC defined at Milestone B.

Growth Parameter	DoD Criteria (moderate / high growth)	U.S. Code (Title 10)
RDT&E	+30% / +50%	N/A
PAUC	+30% / +50%	+30% / +50% (Nunn-McCurdy)
IOC	+12 months / +24 months *since milestone B*	+6 months *since prior quarterly SAR* (10 USC 2432)

- Using the Dec 2007 SAR data and the above evaluation criteria, the portfolio growth profile appears in the following table.

Category	Programs by Category	Total Acquisition Cost by Category
Low Growth	40%	15%
Moderate Growth	47%	72%
High Growth	13%	13%

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Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Michael J. Sullivan, (202) 512-4841 or sullivanm@gao.gov

Staff Acknowledgments

In addition to the contact named above, the following individuals made key contributions to this report: John Oppenheim (Assistant Director), Noah Bleicher, Alexandra Dew, Margaret Holmes, David Messman, Susan Neill, and Ann Marie Udale.